

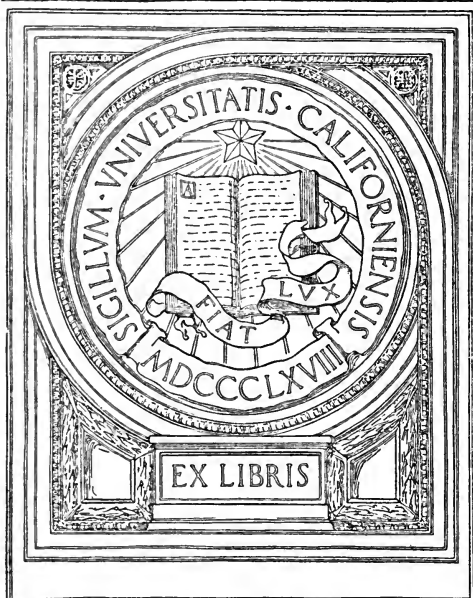
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A MANUAL
OF
QUALITATIVE ANALYSIS
AND OF
CLINICAL MEDICAL CHEMISTRY,
FOR
PHYSICIANS AND STUDENTS.

BY
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SOCIETY, MEMBER OF THE SOCIÉTÉ CHIMIQUE DE PARIS, HONORARY FELLOW OF
THE SOCIETY OF BIOLOGICAL CHEMISTRY.

THIRD EDITION
REVISED AND ENLARGED.

PHILADELPHIA:
JOHN JOS. McVEY.

1900.

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PREFACE TO THE THIRD EDITION.

THE success of preceding editions has rendered any material alterations in plan unadvisable. In the present rewriting, however, the scope of the work has been enlarged by several added chapters, as well as by numerous minor additions throughout. Statements and tests already presented have been critically examined, and, where necessary, revised.

As it now stands, the book presents a synopsis of the Non-Metals, an outline of Qualitative Analysis with analytical schemes for both simple salts and complex mixtures, tests for the Alkaloids, the principles of Volumetric Quantitative Analysis, a section on the three organic classes of chief physiological interest—the Carbohydrates, the Proteids, and the Fats, with a brief description of Ferments and Fermentation. The clinical section of the book treats of the Blood, the Urine, the Sweat, the Saliva, the Gastric Fluid, the Pancreatic Fluid, the Intestinal Fluid, Bile, Milk, and Water. This section is written in more detail, and includes, with the clinical tests possible with limited laboratory equipment, some of the more elaborate and exact methods used in advanced research. The Appendix, together with tables of Weights and Measures, contains a list of the Acid Radicals, a list of the Common Salts arranged according to solubility, a list of Reagents, with formulæ and methods of preparation, and, finally, a complete list of the Poisons and Methods of Treatment.

For valuable suggestions I am indebted to my friends: Joseph C. Guernsey, A. M., M. D., and Raymond J. Harris, A. M., M. D., of Philadelphia, to A. B. Griffiths, Ph. D., F. R. S. E., of London, and to E. W. Carlier, M. D., D. Sc., and T. H. Milroy, M. D.; D. Sc., of the University of Edinburgh.

C. P.

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PART I.

QUALITATIVE ANALYSIS

AND

VOLUMETRIC QUANTITATIVE ANALYSIS.

TABLE OF THE ELEMENTS.

Names and Symbols with Common Valence.	Atomic Weights.			Names and Symbols with Common Valence.	Atomic Weights.		
	B.P.*	U.S.P.†	F.W.C.‡		B.P.*	U.S.P.†	F.W.C.‡
Aluminum, Al ₂ ^{vi}	27.0	27.04	27.1	Manganese, Mn ⁱⁱ , Mn ₂ ^{vi}	55.0	54.8	55.0
Antimony, Sb ⁱⁱⁱ	120.0	119.6	120.4	Mercury, Hg ₂ ⁱⁱ , Hg ^{vi}	200.0	199.8	200.0
Arsenic, As ⁱⁱⁱ	75.0	74.9	75.0	Molybdenum, Mo ^{vi}	96.0	95.9	96.0
Barium, Ba ⁱⁱ	136.8	136.3	137.4	Nickel, Ni ⁱⁱ	58.6	58.6	58.70
Bismuth, Bi ⁱⁱⁱ	208.0	208.9	208.1	Nitrogen, N ⁱⁱⁱ , v	14.0	14.01	14.04
Boron, B ⁱⁱⁱ	11.0	10.9	11.0	Osmium, Os ^{iv}	185.	190.3	191.0
Bromine, Br ⁱ	80.0	79.76	79.95	Oxygen, O ⁱⁱ	16.0	15.96	16.0
Cadmium, Cd ⁱⁱ	112.0	111.5	112.4	Palladium, Pd ^{iv}	106.2	106.35	107.0
Cæsium, Cs ⁱ	133.0	132.7	132.9	Phosphorus, P ⁱⁱⁱ , v	31.0	30.96	31.0
Calcium, Ca ⁱⁱ	40.0	39.91	40.1	Platinum, Pt ^{iv}	194.4	194.3	194.9
Carbon, C ⁱⁱ , iv	12.0	11.97	12.0	Potassium, K ⁱ	39.0	39.03	39.11
Cerium, Ce ⁱⁱⁱ	141.5	139.9	139.0	Rubidium, Rb ⁱ	85.4	85.2	85.4
Chlorine, Cl ⁱ	35.5	35.37	35.45	Selenium, Se ^{iv}	78.9	78.87	79.2
Chromium, Cr ⁱⁱ , Cr ₂ ^{vi}	52.5	52.0	52.1	Silicon, Si ^{iv}	28.0	28.3	28.4
Cobalt, Co ⁱⁱ	58.6	58.6	59.0	Silver, Ag ⁱ	108.0	107.66	107.92
Columbium, Cb ^v	94.0	93.7	93.7	Sodium, Na ⁱ	23.0	23.0	23.05
Copper, Cu ₂ ⁱⁱ , Cu ⁱⁱ	63.3	63.18	63.6	Strontium, Sr ⁱⁱ	87.5	87.3	87.6
Fluorine, F ⁱ	19.0	19.0	19.05	Sulphur, S ⁱⁱ , iv	32.0	31.98	32.07
Gold, Au ⁱ , iii	197.0	196.7	197.2	Tellurium, Te ⁱⁱ , iv	125.0	125.0	127.5
Hydrogen, H ⁱ	1.0	1.0	1.008	Tin, Sn ⁱⁱ , iv	118.0	118.8	119.0
Iodine, I ⁱ	127.0	126.53	126.85	Titanium, Ti ^{iv}	48.0	48.0	48.15
Iridium, Ir ^{iv}	193.0	192.5	193.1	Tungsten, W ^{vi}	184.0	183.6	184.0
Iron, Fe ⁱ , Fe ₂ ^{vi}	56.0	55.88	56.6	Uranium, U ^{vi}	240.0	238.8	239.6
Lead, Pb ⁱⁱ	206.4	206.4	206.92	Vanadium, V ^v	51.0	51.1	51.4
Lithium, Li ⁱ	7.0	7.01	7.03	Zinc, Zn ⁱⁱ	64.9	65.1	65.4
Magnesium, Mg ⁱⁱ	24.0	24.3	24.3	Zirconium, Zr ^{iv}	90.4	90.4	90.4

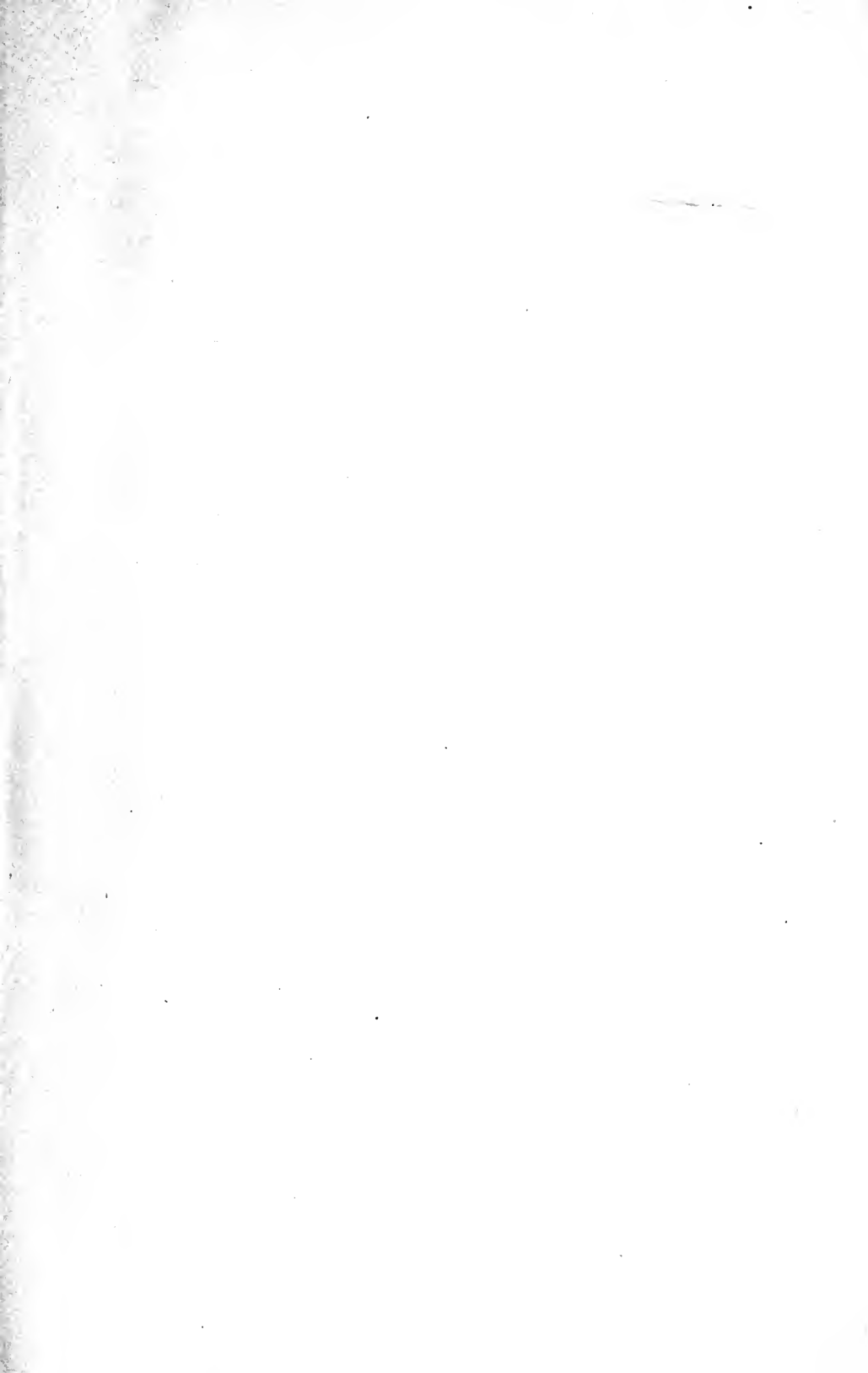
In addition to the above may be mentioned Argon, A, Beryllium, Be (also known as Glucinum, Gl), Erbium, Er, Gadolinium, Gd, Gallium, Ga, Germanium, Ge, Helium, He, Indium, In, Lanthanum, La, Neodidymium, Nd, Praseodidymium, Pr, Rhodium, Rh, Ruthenium, Ru, Samarium, Sm, Scandium, Sc, Tantalum, Ta, Terbium, Tb, Thallium, Tl, Thorium, Th, Thulium, Tu, Ytterbium, Yb, Yttrium, Yt.

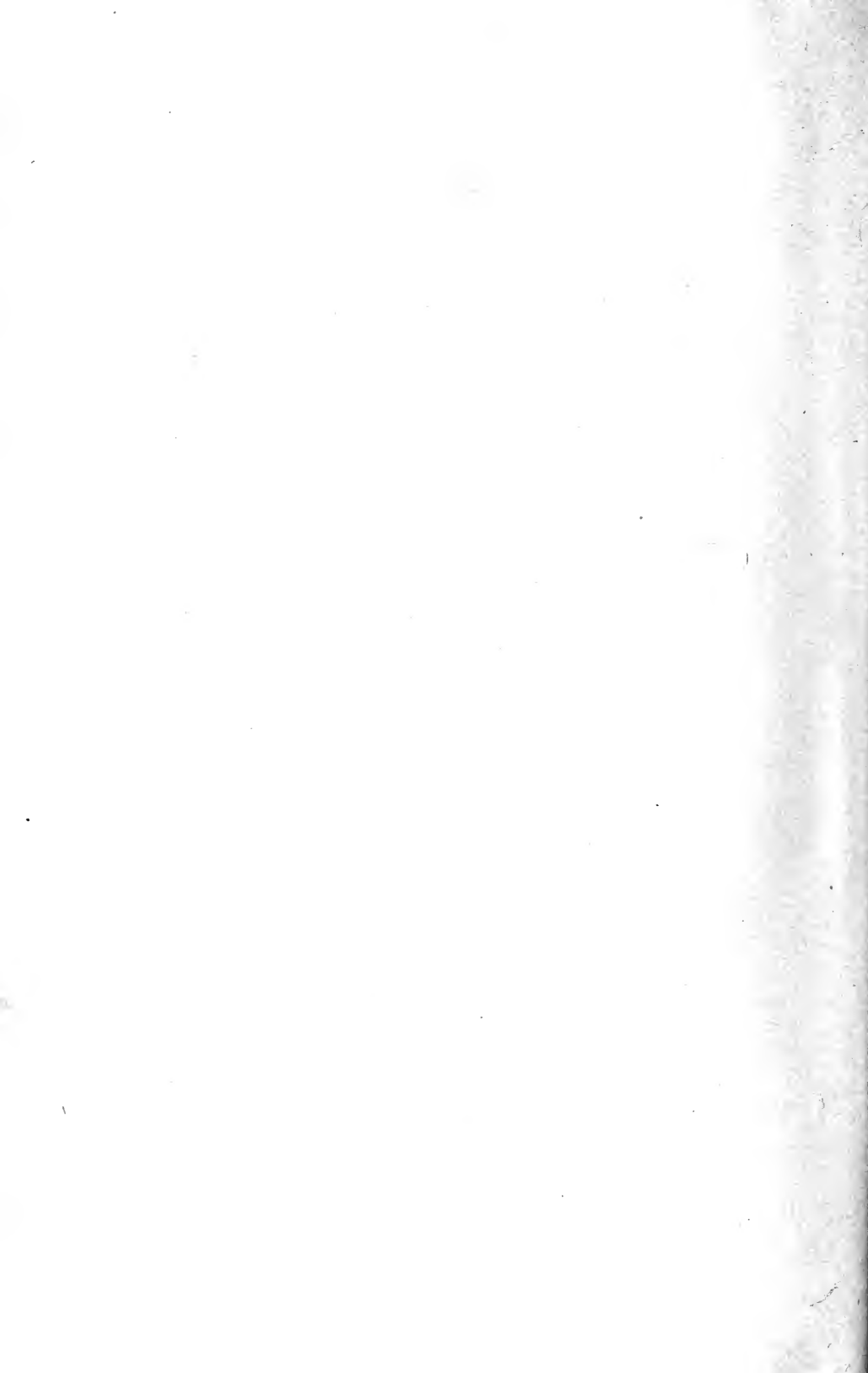
Columbium, named in the list, is also known as Niobium, Nb.

* British Pharmacopœia, H = 1, O = 16.

† United States Pharmacopœia, H = 1. Atomic weights after Meyer and Seubert.

‡ F. W. Clarke. Report of Committee of American Chemical Society. See Journal of the American Chemical Society, February, 1900. O = 16.





THE NON-METALS.*

HYDROGEN.

Prepared. 1.) By the action of zinc on sulphuric acid. 2.) By the action of sodium on water. 3.) By the electrolytic decomposition of water. *Properties.* Colorless, odorless, tasteless gas. Lightest substance known. Is inflammable, burning with a pale bluish flame. The mixture with air is explosive.

OXYGEN.

Prepared. 1.) By heating mercuric oxide. 2.) By heating potassium chlorate, best after addition of a little manganese dioxide. *Properties.* Colorless, odorless, tasteless gas, a little heavier than air, only slightly soluble in water. It is incombustible, but is a supporter of combustion. It unites readily with most other elements forming oxides; with non-metals, acid oxides, with metals, basic oxides.

OZONE, O_3 (Oxygen, O_2), *Prepared.* 1.) By moistening a mixture of potassium permanganate and barium dioxide with sulphuric acid. 2.) By the slow oxidation of moist phosphorus. 3.) By electric discharge through air or oxygen. *Properties.* A gas with characteristic odor, an oxidizing agent, soluble in oils. A paper impregnated with starch and potassium iodide becomes blue when exposed to the gas.

WATER. May be made by burning hydrogen in air, by exploding a mixture of hydrogen and oxygen, by the reaction between a true base and a true acid. It may be decomposed by high temperatures and by electrolysis. It is purified by sedimentation, by filtration, by boiling, and by distillation. A water has a "temporary hardness" when it contains carbonates of calcium and

* The division into Non-Metals and Metals in this book is based upon the part played by the various elements in chemical analysis. For this reason arsenic, antimony, and bismuth, ordinarily regarded as non-metals, are here classed with the metals and grouped with copper, tin, mercury and cadmium.

magnesium; it has a "permanent hardness" when it contains the sulphates of the same elements.

HYDROGEN DIOXIDE. *Prepared.* By the action of an acid on barium dioxide. *Properties.* A colorless liquid without odor, but with a characteristic taste. The strong solutions quickly decompose, the dilute solutions are more stable. The usual strength is a three per cent. by weight solution giving off ten volumes of available oxygen. For tests see Index.

NITROGEN.*

Prepared. 1.) By passing air over incandescent copper, the metal uniting with the oxygen present. 2.) By heating ammonium nitrite. *Properties.* A colorless, odorless, tasteless gas, a little lighter than air, incombustible, a non-supporter of combustion, does not support life, is not poisonous.

AMMONIA, NH_3 . *Prepared.* 1.) By mixing equal parts of ammonium chloride and calcium hydroxide, and warming. 2.) By treating ammonium chloride, dry, or in solution, with an alkali. 3.) By boiling a solution of ammonium hydroxide. *Properties.* A colorless gas with characteristic odor; will burn in pure oxygen, but not in air; very soluble in water, the solution being known as ammonium hydroxide. The radical, NH_4 , ammonium, forms compounds similar to those of the alkali metals.

NITROGEN MONOXIDE, N_2O . (Nitrous oxide). *Prepared* by heating ammonium nitrate. *Properties.* A colorless, odorless gas, with a faint sweetish taste, producing anaesthesia when inhaled.

NITROGEN DIOXIDE, N_2O_2 . (Nitric oxide.) A colorless gas.

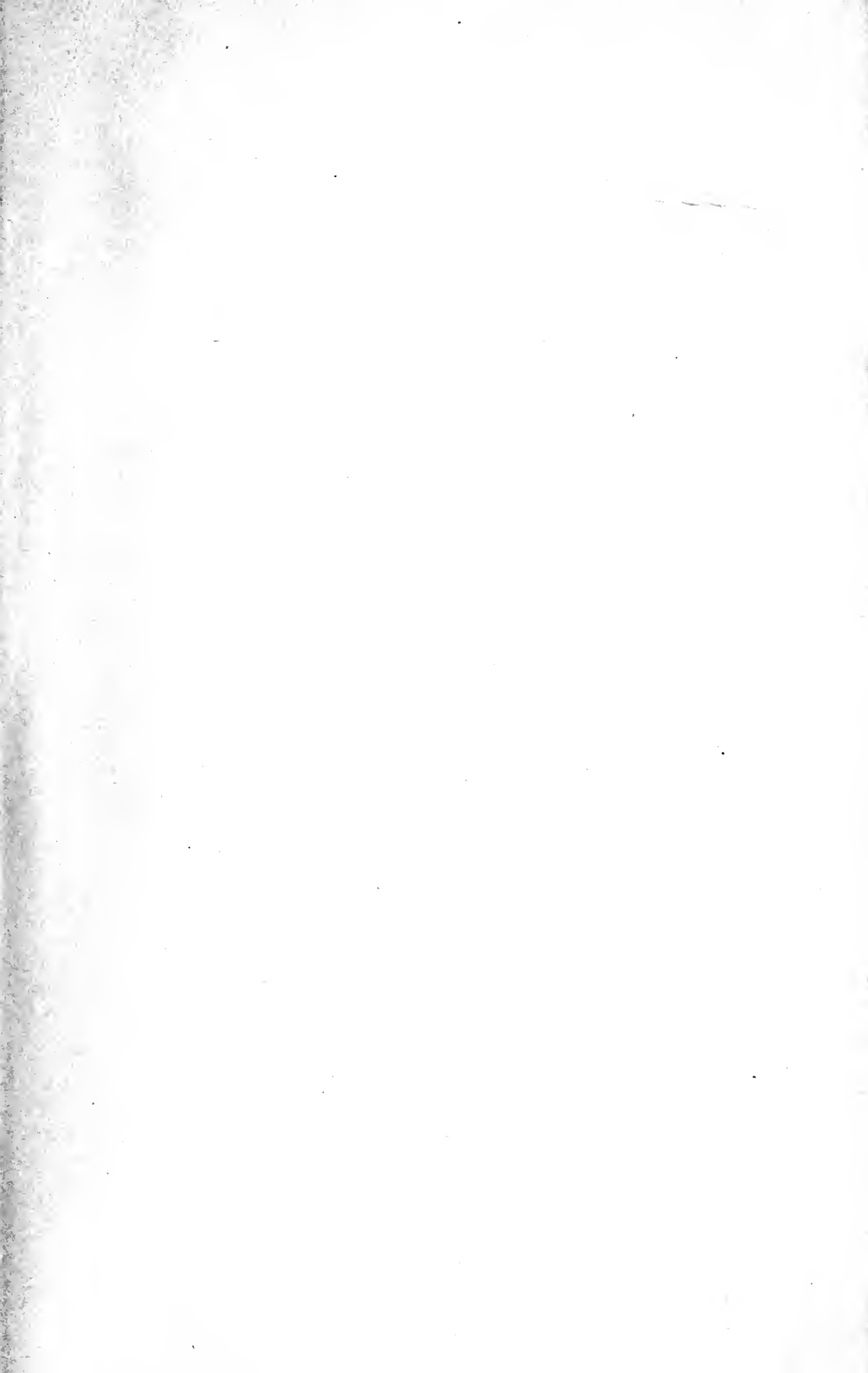
NITROGEN TRIOXIDE, N_2O_3 . (Nitrous anhydride.) A blue liquid with low boiling point, with water forming nitrous acid.

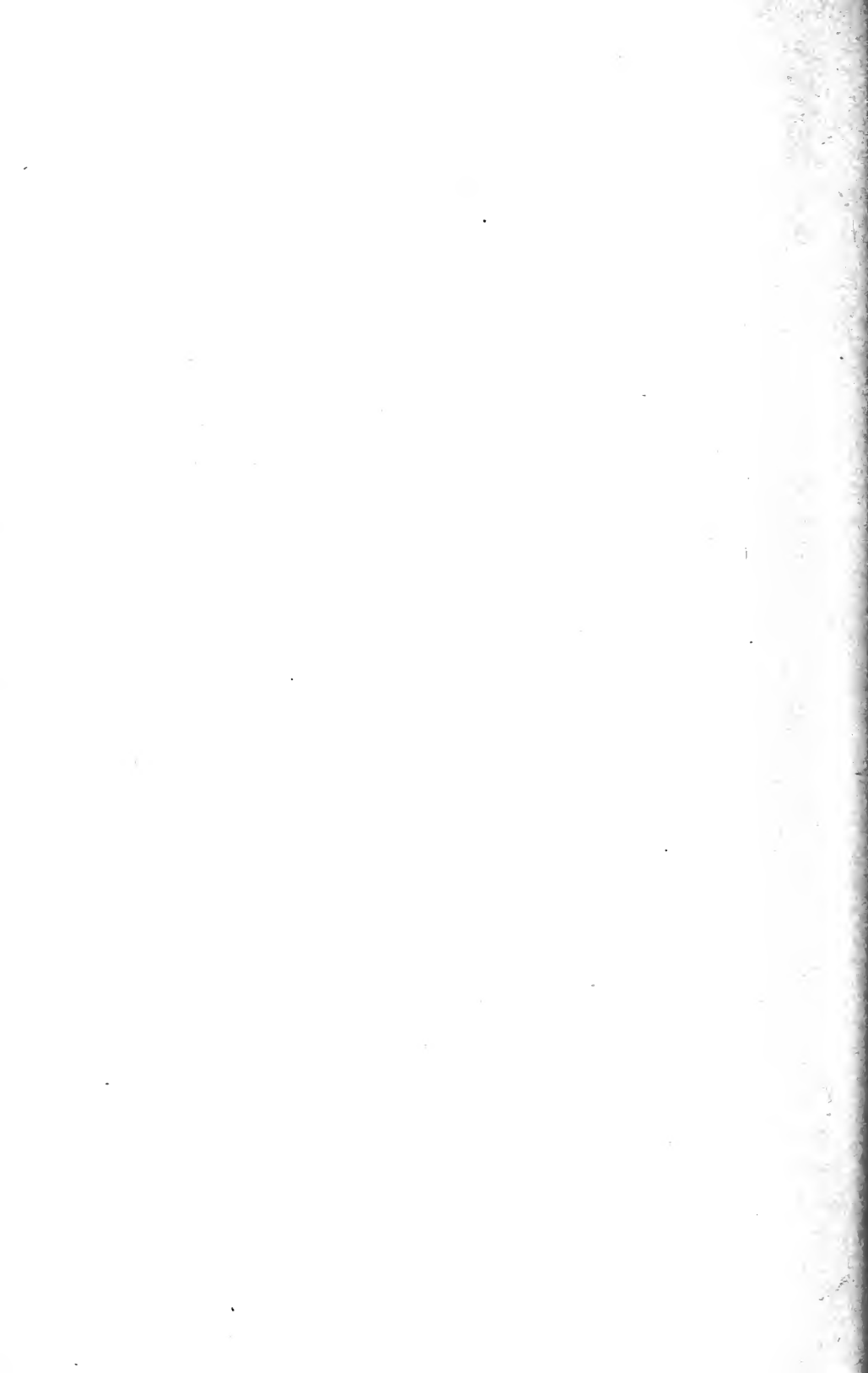
NITROGEN TETROXIDE, N_2O_4 . (Nitrogen peroxide.) A colorless liquid at low temperatures; at higher temperatures a reddish-brown gas, 2NO_2 .

NITROGEN PENTOXIDE, N_2O_5 . (Nitric anhydride.) A crystalline substance forming, with water, nitric acid. Practically nitric acid is made by treating sodium nitrate with sulphuric acid.

ATMOSPHERE. The essential ingredients of the atmosphere are Nitrogen, about 77.5 per cent.; Oxygen, 20.6 per cent.; Carbon dioxide, 0.03–0.04 per cent.; Aqueous vapor, 0.5–1.4 per cent. Other ingredients may be styled accidental. The carbon dioxide

* Tests for compounds, see Index.





and water may be estimated by passing a measured volume of air through two weighed tubes, the first, containing calcium chloride, absorbs water, the second, containing potassium hydroxide, absorbs carbon dioxide. From the increase in weight of the tubes the amounts of carbon dioxide and water in the air may be calculated.

THE HALOGEN ELEMENTS.*

FLUORINE. Fluorine is rare in the free state. The acid of fluorine, Hydrofluoric acid, HF, may be made by treating powdered calcium fluoride with sulphuric acid. It is a powerful corrosive, attacks glass, and is used in etching of glass. Vapors are dangerous.

CHLORINE. *Prepared.* 1.) By the action of sulphuric acid and manganese dioxide on sodium chloride. 2.) By action of hydrochloric acid on manganese dioxide. *Properties.* A yellowish-green gas, with suffocating odor, soluble in water ("chlorine water"). Its mixture with hydrogen explodes when exposed to the light. Acts as an oxidizing agent and bleach.

Hydrochloric acid is prepared by the action of sulphuric acid on sodium chloride.

BROMINE. *Prepared,* by the action of sulphuric acid and manganese dioxide on potassium bromide. *Properties.* A dark reddish-brown, volatile liquid, giving off pungent, irritating fumes. It is slightly soluble in water, forming "bromine water."

Hydrobromic acid may be made by the action of water on phosphorus tribromide.

IODINE. *Prepared,* by the action of sulphuric acid and manganese dioxide on potassium iodide. *Properties.* It is a crystalline substance, volatile, giving off violet-colored vapors with a pungent odor. It is very slightly soluble in pure water, but is soluble in water containing potassium iodide, and in alcohol and in chloroform.

Hydriodic acid may be made by the action of water on phosphorus tri-iodide.

PHOSPHORUS.*

Prepared, from tricalcic phosphate, $\text{Ca}_3(\text{PO}_4)_2$; this substance is converted into phosphoric acid and the latter is then reduced by heating with carbon. *Properties.* Two varieties. Ordinary Phosphorus is a waxy semi-transparent solid with characteristic odor,

* Tests for compounds, see Index.

giving off luminous fumes. It oxidizes on exposure to air, is kept under water, is soluble in carbon disulphide and in oils, and is strongly poisonous.

Red or Amorphous Phosphorus is made by heating the ordinary variety for several days in a closed tube. It is a red amorphous powder, does not give off fumes, is not luminous in the dark, is not soluble in carbon disulphide, nor in oils, and is not poisonous.

SULPHUR.*

Prepared, by refining the crude sulphur of nature. *Properties*. Ordinary sulphur is a yellow brittle solid, or a fine yellow powder, insoluble in water, very slightly soluble in alcohol, soluble in carbon disulphide. It melts when heated, and, in the air, burns to sulphur dioxide.

HYDROGEN SULPHIDE, or Hydrosulphuric acid, is prepared by the action of an acid, preferably hydrochloric acid on ferrous sulphide. It is an inflammable gas, with characteristic odor, used in chemical analysis.

SULPHUR DIOXIDE, SO_2 . *Prepared*, by burning sulphur. It is a colorless gas with suffocating odor; it is soluble in water forming sulphurous acid.

SULPHUR TRIOXIDE, SO_3 . *Prepared*, by oxidation of sulphur dioxide, is generally in crystal form. Dissolved in water it gives sulphuric acid.

CARBON.*

Occurs in nature in three allotropic forms, the clear isometric crystal diamond, the black hexagonal crystal graphite, and the amorphous variety as found in soot, charcoal, etc. Carbon resists the action of many ordinary reagents, but at high temperatures it has a strong affinity for oxygen and is therefore a valuable reducing agent.

CARBON MONOXIDE, CO (Carbonic oxide). *Prepared*. 1.) By burning carbon with an insufficient supply of oxygen. 2.) By warming a mixture of 1 part crystalline potassium ferrocyanide and 10 parts of strong sulphuric acid. *Properties*. A colorless, odorless gas, very slightly soluble in water, a non-supporter of combustion. Heated in the air it burns with a pale bluish flame. It is strongly poisonous.

* Tests for compounds, see Index.

CARBON DIOXIDE, CO_2 (Carbonic anhydride). *Prepared.* 1.) By heating calcium carbonate. 2.) By treating carbonates with acids. *Properties.* It is a colorless gas, generally with a faint acid odor, soluble in water, a non-supporter of combustion, and incombustible. It will not support life but is non-poisonous. Carbonic acid, H_2CO_3 , may be regarded as the compound of carbon dioxide and water.

SILICON.*

The element is obtained in both crystalline and amorphous forms but does not occur in the free state in nature.

SILICON DIOXIDE, SiO_2 (Silica). Occurs in nature as rock crystal, agate, quartz sand, etc. It is a hard, infusible substance, not attacked by ordinary acids, but dissolves in hydrofluoric acid, and is decomposed by fusion with alkali carbonates. The Silicates are salts of silicic acids, H_4SiO_4 , H_2SiO_3 , etc.

BORON.*

Rare as an element. Boric acid, H_3BO_3 , is a crystalline substance, slightly soluble in water, more soluble in alcohol. Other compounds are, Boric anhydride, B_2O_3 , Metaboric acid, HBO_2 , Tetraboric acid, $\text{H}_2\text{B}_4\text{O}_7$. The sodium salt of tetraboric acid is known as Borax.

* Tests for compounds, see Index.

THE METALS.

CLASSIFICATION FOR PURPOSES OF ANALYSIS.

THE metals are commonly divided into five groups, according to their behavior with certain general, or *group reagents*; as follows:

GROUP I.—Metals forming *chlorides* insoluble in water, and consequently precipitated from solutions of their salts by Hydrochloric Acid. *Lead, Silver, Mercury (Mercurous).*

GROUP II.—Metals forming *sulphides* insoluble in water and in dilute acids, precipitated from solutions of their salts by Hydrogen Sulphide.

(a) Sulphides soluble in Ammonium Sulphide and in Sodium or Potassium Hydroxides. *Arsenic, Antimony, Tin, Gold, Platinum.*

(b) Sulphides insoluble in Ammonium Sulphide and in Sodium or Potassium Hydroxides. *Mercury (Mercuric), Bismuth, Copper, Cadmium.*

GROUP III.—Metals forming *sulphides* and *hydroxides*, which are decomposed by acids, but which are insoluble in water, precipitated from neutral solutions by Ammonium Sulphide. *Iron, Manganese, Aluminum, Chromium, Cobalt, Nickel, Zinc.*

GROUP IV.—Metals forming sulphides soluble in water or decomposed by dilute acids, but whose *carbonates* are insoluble, precipitated from solutions of their salts by Ammonium Carbonate. *Barium, Strontium, Calcium (Magnesium).*

GROUP V.—Metals forming chlorides, sulphides, and carbonates soluble in water, and not precipitated by the preceding group reagents. *Potassium, Sodium, Lithium.* (The basic radical *Ammonium*, NH_4 , is commonly included with this group.)

TESTS FOR THE METALS.

GROUP V. The "Alkali Group."

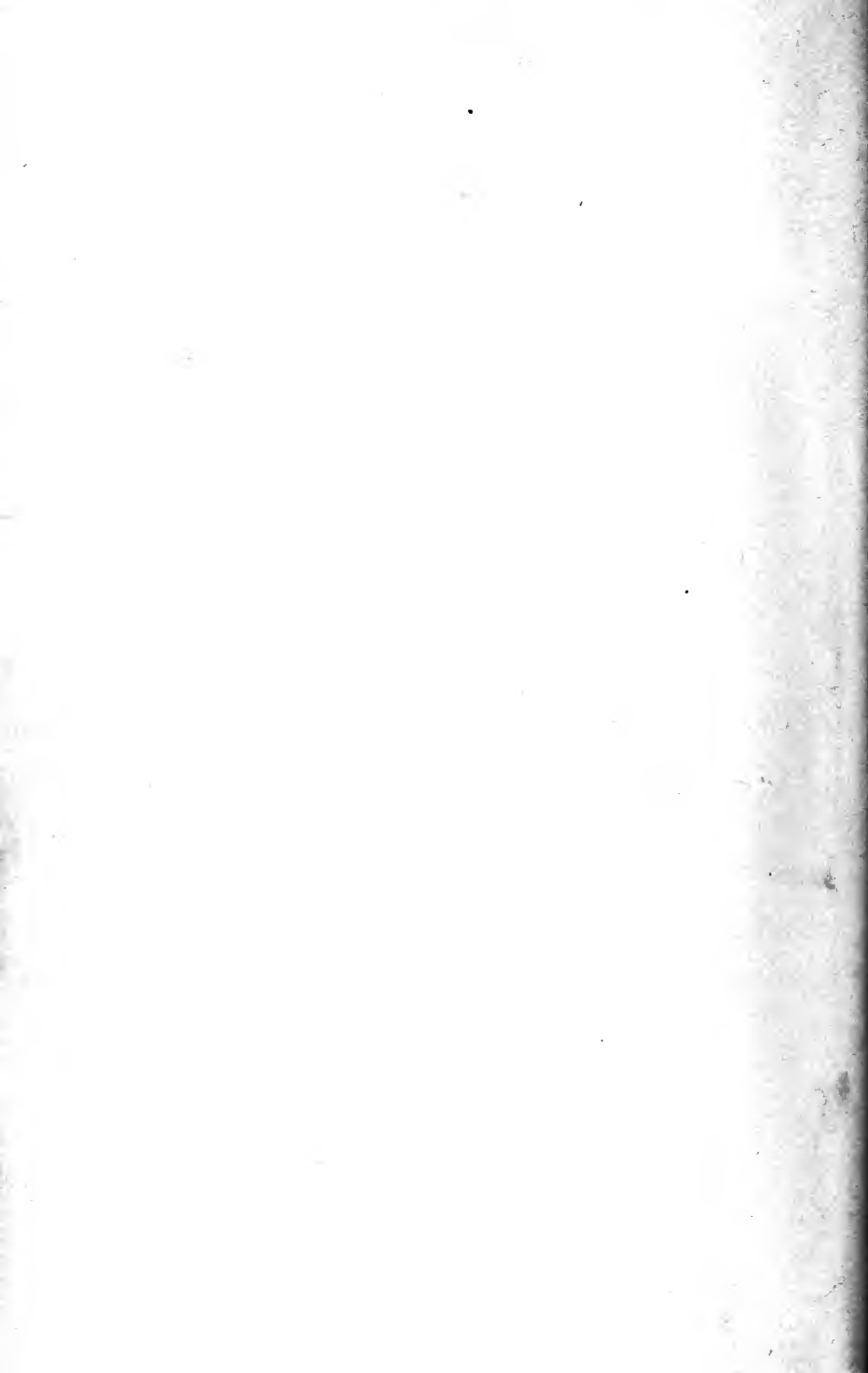
Potassium, K, Sodium, Na, Lithium, Li, (Ammonium, NH_4).

POTASSIUM.

(Use KCl, Solution or Solid.)

1.—Test on clean platinum wire, in Bunsen flame, observe the

Furans with H₂ Ma UV KOH. Shikhar
Furane Reddish brown ppt. w/ H₂ R₃ HC 5) 6.



violet color developed. In presence of sodium compounds the yellow rays produced thereby may be excluded by use of blue glass.

2.— PtCl_4 precipitates from solutions of potassium salts, yellow crystalline, potassium platinic chloride, K_2PtCl_6 , soluble in excess of water and in alkalies but insoluble in acids or in alcohol.

3.— $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ precipitates from concentrated neutral solutions of potassium salts, white, crystalline, potassium hydrogen tartrate, $\text{KHC}_4\text{H}_4\text{O}_6$.

Potassium hydroxide, caustic potash, has no odor, has a peculiar "soapy feel," and, with solution of mercuric chloride, gives an orange-yellow precipitate.

Potassium carbonate is similar, but may be recognized by the effervescence with acids.

SODIUM.

(Use NaCl , Solution or Solid.)

1.—Test on platinum wire, in Bunsen flame, observe the bright yellow color developed.

2.—Potassium pyroantimonate, $\text{H}_2\text{K}_2\text{Sb}_2\text{O}_7$, precipitates from concentrated solutions of sodium salts, a white, crystalline, sodium pyroantimonate $\text{H}_2\text{Na}_2\text{Sb}_2\text{O}_7$.

3.—Neither PtCl_4 , nor $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$, give precipitates with sodium salts. Compare Potassium and Ammonium.

Sodium hydroxide, caustic soda, has no odor, has a peculiar "soapy feel," and, with solution of mercuric chloride, gives an orange-yellow precipitate.

Sodium carbonate is similar, but may be recognized by the effervescence with acids.

LITHIUM.

(Use LiCl , Solution.)

1.—Lithium compounds color the non-luminous flame crimson, or carmine red.

2.— Na_2HPO_4 precipitates from hot solutions of lithium salts, lithium phosphate, Li_3PO_4 , best after addition of NaOH .

3.— Na_2CO_3 precipitates, from cold concentrated solutions Li_2CO_3 , soluble in 100 parts of water.

4.— PtCl_4 and $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ give no precipitates.

AMMONIUM.

(Use NH_4OH and $(\text{NH}_4)_2\text{SO}_4$.)

1.—Note the odor of NH_4OH .

2.—Note the action of the fumes on red litmus paper.

3.—Upon one watch-glass place a drop of NH_4OH , upon another

a drop of HCl. Observe the white fumes of NH_4Cl produced when the glasses are brought together.

4.—Test a solution of $(\text{NH}_4)_2\text{SO}_4$. Note that no odor is given off. Add a few drops of NaOH, and heat. Note the characteristic odor of ammonia.

5.—When a powder is to be tested, mix a little of it with $\text{Ca}(\text{OH})_2$ on a watch glass; moisten with water and cover with a second watch glass, to the inner side of which is adherent a piece of red litmus paper. The presence of an ammonium compound will be shown by the litmus paper turning blue.

6.— PtCl_4 , and $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ produce precipitates with ammonium salts resembling those produced from solutions of potassium compounds.

Ammonium hydroxide has a characteristic odor, and gives a white precipitate with solutions of mercuric chloride.

Ammonium carbonate is similar, but may be recognized by the effervescence with acids.

For the separation of members of this group, see p. 29.

GROUP IV. Metals of the "Alkaline Earths."

Barium, Ba, Strontium, Sr, Calcium, Ca, Magnesium, Mg.

BARIUM.

(Use BaCl_2 , Solution.)

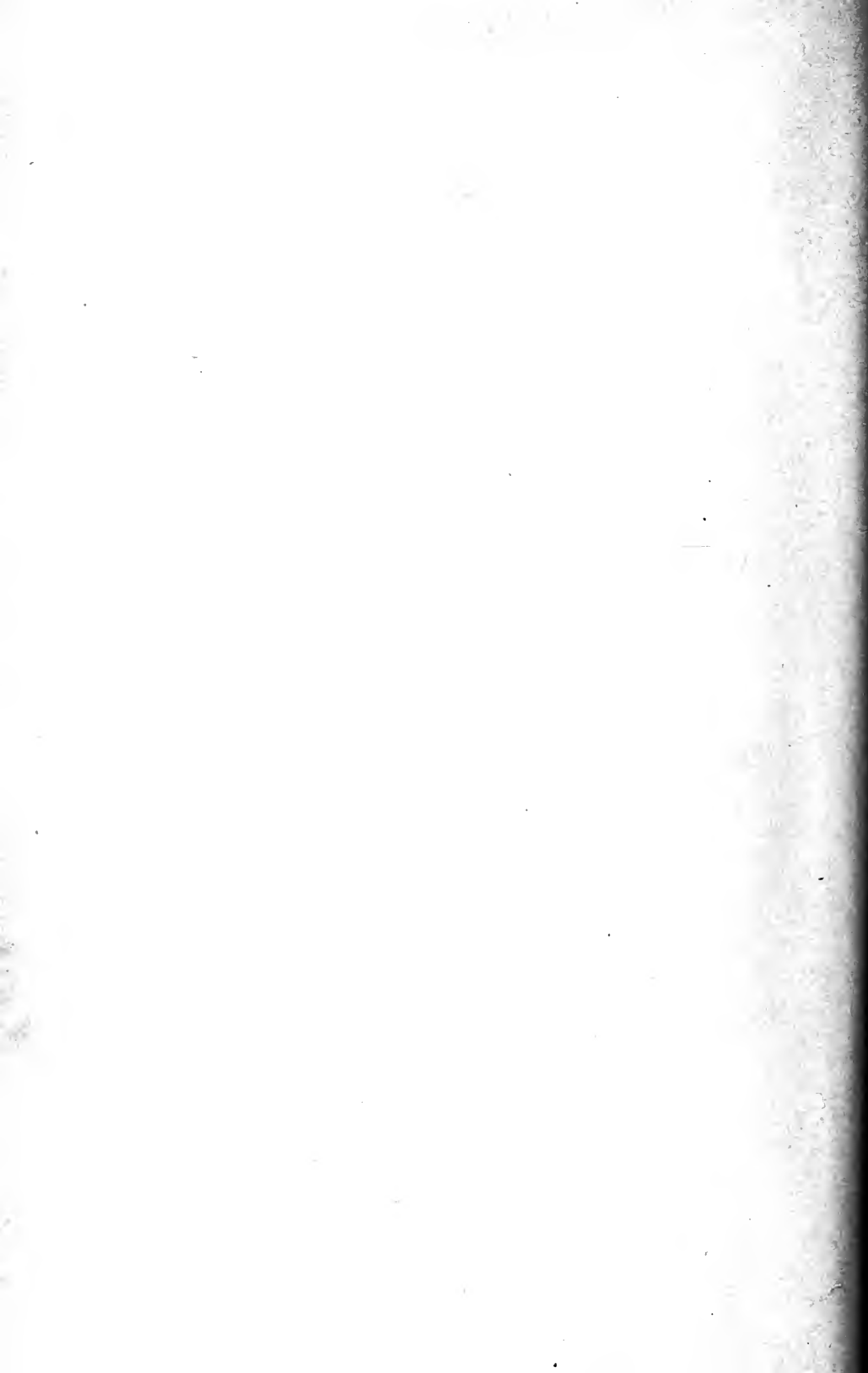
- 1.— $(\text{NH}_4)_2\text{CO}_3$ precipitates white barium carbonate, BaCO_3 .
- 2.— H_2SO_4 (dil.) and all soluble sulphates precipitate white barium sulphate, BaSO_4 , insoluble in boiling, ammoniacal $(\text{NH}_4)_2\text{SO}_4$.
- 3.— Na_2HPO_4 precipitates white barium phosphate, BaHPO_4 , soluble in $\text{HC}_2\text{H}_3\text{O}_2$.
- 4.— K_2CrO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ precipitate yellow barium chromate, BaCrO_4 , insoluble in dilute $\text{HC}_2\text{H}_3\text{O}_2$ but soluble in HCl.
- 5.—Barium compounds impart a green color to the flame.

STRONTIUM.

(Use $\text{Sr}(\text{NO}_3)_2$, Solution.)

- 1.— $(\text{NH}_4)_2\text{CO}_3$ precipitates white strontium carbonate, SrCO_3 .
- 2.— H_2SO_4 (dil.) and soluble sulphates precipitate white strontium sulphate, SrSO_4 , insoluble in boiling, ammoniacal $(\text{NH}_4)_2\text{SO}_4$.
- 3.— K_2CrO_4 precipitates, slowly, from strong alkaline solu-





tions, yellow strontium chromate, SrCrO_4 , soluble in $\text{HC}_2\text{H}_3\text{O}_2$. $\text{K}_2\text{Cr}_2\text{O}_7$ gives no precipitate.

4.—Strontium compounds impart an intense red or crimson color to the flame.

CALCIUM.

(Use CaCl_2 Solution.)

1.— $(\text{NH}_4)_2\text{CO}_3$ precipitates white calcium carbonate, CaCO_3 from ordinary but not from highly dilute solutions.

2.—From strong solutions H_2SO_4 precipitates white calcium sulphate, CaSO_4 , soluble in an excess of water and in boiling, ammoniacal $(\text{NH}_4)_2\text{SO}_4$.

3.— Na_2HPO_4 precipitates white calcium phosphate, CaHPO_4 , soluble in $\text{HC}_2\text{H}_3\text{O}_2$.

4.— $(\text{NH}_4)_2\text{C}_2\text{O}_4$ precipitates white calcium oxalate, CaC_2O_4 , soluble in HCl , insoluble in $\text{HC}_2\text{H}_3\text{O}_2$.

5.—Calcium compounds impart a yellowish-red color to the flame.

MAGNESIUM.

(Use MgCl_2 Solution.)

1.— $(\text{NH}_4)_2\text{CO}_3$ precipitates, slowly, from strong solutions, white magnesium carbonate, MgCO_3 . The precipitation is hastened by warming, but is prevented by presence of NH_4Cl .

2.— NH_4OH precipitates part of the magnesium as $\text{Mg}(\text{OH})_2$, but the precipitation is prevented by presence of NH_4Cl , and, also, by too great dilution. NaOH gives a more complete precipitation.

3.— Na_2HPO_4 , in presence of NH_4Cl and NH_4OH , precipitates crystalline NH_4MgPO_4 . In dilute solutions the precipitate forms slowly.

4.—Neither H_2SO_4 nor K_2CrO_4 precipitate salts of magnesium
For the separation of members of this group, see pages 28 and 29.

GROUP III.

Aluminum, Al, Chromium, Cr, Iron, Fe, Nickel, Ni, Cobalt, Co,
Manganese, Mn, Zinc, Zn.

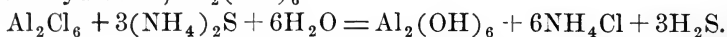
ALUMINUM.

(Use Solution of Al_2Cl_6 .)

1.— NH_4OH precipitates white aluminum hydroxide, $\text{Al}_2(\text{OH})_6$, insoluble in moderate excess.

2.—NaOH precipitates white aluminum hydroxide, $\text{Al}_2(\text{OH})_6$. Soluble in excess of the reagent, but reprecipitated by boiling with excess of NH_4Cl .

3.—Both $(\text{NH}_4)_2\text{S}$ and $(\text{NH}_4)_2\text{CO}_3$ precipitate white aluminum hydroxide, $\text{Al}_2(\text{OH})_6$.



4.— Na_2HPO_4 , in presence of sodium acetate, precipitates aluminum phosphate, $\text{Al}_2(\text{PO}_4)_2$. The precipitate is soluble in sodium or potassium hydroxide, in HCl, or in HNO_3 ; it is insoluble in NH_4OH , NH_4Cl , or in $\text{HC}_2\text{H}_3\text{O}_2$.

5.—Heated in the borax bead a clear glass is obtained.

CHROMIUM.

(Use Cr_2Cl_6 Solution.)

1.— NH_4OH precipitates light green chromium hydroxide, $\text{Cr}_2(\text{OH})_6$.

2.—NaOH precipitates light green chromium hydroxide, $\text{Cr}_2(\text{OH})_6$. Soluble in excess but precipitated again on boiling.

3.— $(\text{NH}_4)_2\text{S}$ precipitates light green chromium hydroxide, $\text{Cr}_2(\text{OH})_6$.

4.—Fused with a mixture of KNO_3 and Na_2CO_3 on platinum foil, yellow sodium and potassium chromates are formed, soluble in water.

5.—Acidify the solution obtained in the last test, with $\text{HC}_2\text{H}_3\text{O}_2$ and then add $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ —a yellow precipitate of lead chromate, PbCrO_4 , is formed.

6.—Borax bead; oxidizing flame (O. F.) yellow or reddish when hot, yellow-green when cold. Reducing flame (R. F.) green, hot and cold.

Tests for chromates, see p. 32.

IRON.

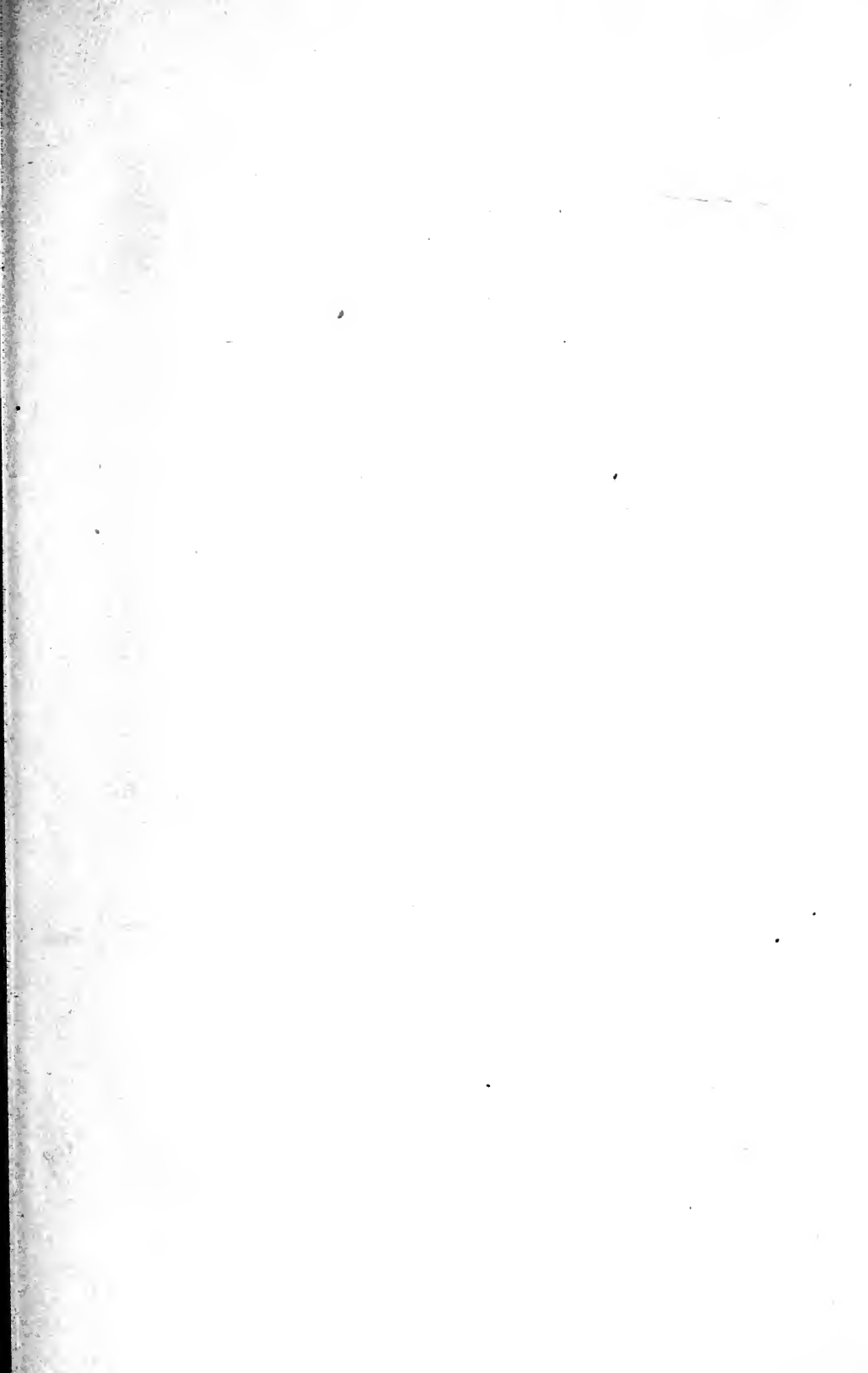
FERROUS COMPOUNDS. (Use FeSO_4 Solution.)

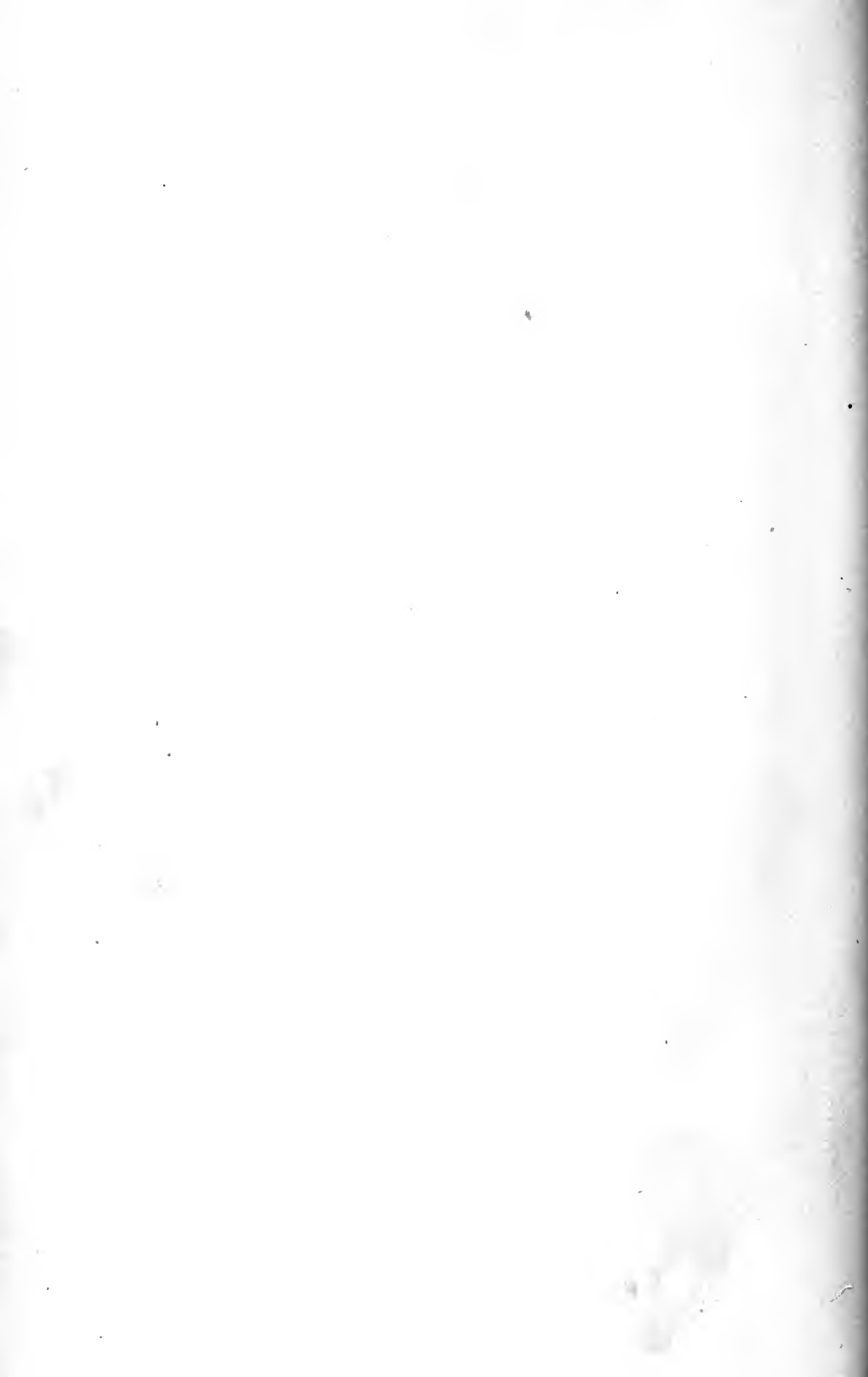
1.—NaOH or NH_4OH precipitates white, or greenish-white, $\text{Fe}(\text{OH})_2$, turning brown on exposure to the air.

2.— $(\text{NH}_4)_2\text{S}$ precipitates black ferrous sulphide, FeS .

3.— $\text{K}_4\text{Fe}(\text{CN})_6$ precipitates bluish-white potassium ferrous ferrocyanide, $\text{K}_2\text{Fe}_2(\text{CN})_6$.

4.— $\text{K}_3\text{Fe}(\text{CN})_6$ precipitates dark blue ferrous ferricyanide, $\text{Fe}_5(\text{CN})_{12}$, known as Turnbull's blue.





5.—K(CN)S gives no reaction.

FERRIC COMPOUNDS. (Use Fe_2Cl_6 Solution.)

1.—NaOH or NH_4OH precipitates reddish-brown ferric hydroxide, $\text{Fe}_2(\text{OH})_6$.

2.— $(\text{NH}_4)_2\text{S}$ precipitates black ferrous sulphide, FeS.

3.— $\text{K}_4\text{Fe}(\text{CN})_6$ precipitates ferric ferrocyanide, $\text{Fe}_7(\text{CN})_{18}$, known as Prussian Blue.

4.— $\text{K}_3\text{Fe}(\text{CN})_6$ produces no precipitate but imparts a green or brown color to the solution.

5.—K(CN)S produces a blood-red color due to the formation of ferric sulphocyanate, $\text{Fe}_2(\text{CNS})_6$. The color is destroyed by addition of HgCl_2 .

6.—Borax bead; O. F. yellow or yellow-red when hot, yellow when cold. R. F. bottle green.

MANGANESE.

(Use MnSO_4 Solution.)

1.—NaOH or NH_4OH precipitates whitish manganous hydroxide, $\text{Mn}(\text{OH})_2$, turning brown and oxidizing, on exposure to the air, to $\text{Mn}_2(\text{OH})_6$. The precipitation by NH_4OH is prevented by presence of NH_4Cl .

2.— $(\text{NH}_4)_2\text{S}$ precipitates flesh colored manganous sulphide, MnS .

3.—Fused with a mixture of KNO_3 and Na_2CO_3 , on platinum foil, green potassium and sodium manganates are formed.

4.—Borax bead, O. F. violet when hot, reddish-violet when cold. R. F. colorless.

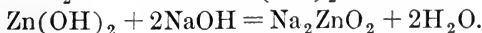
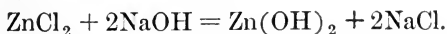
5.—With *manganic* compounds (use solution of Mn_2Cl_6) alkaline hydroxides precipitate brown $\text{Mn}_2(\text{OH})_6$. $(\text{NH}_4)_2\text{S}$ precipitates MnS , as with manganous compounds.

Tests for permanganates, see p. 33.

ZINC.

(Use ZnSO_4 , or ZnCl_2 , Solution.)

1.—NaOH added carefully precipitates white zinc hydroxide, $\text{Zn}(\text{OH})_2$ easily soluble in excess:



2.— NH_4OH precipitates white $\text{Zn}(\text{OH})_2$, soluble in excess.

3.— $(\text{NH}_4)_2\text{S}$ precipitates white zinc sulphide, ZnS , insoluble in $\text{HC}_2\text{H}_3\text{O}_2$, soluble in dilute HCl .

4.— Na_2CO_3 precipitates white, basic carbonate, $\text{Zn}_5(\text{OH})_6(\text{CO}_3)_2$, insoluble in excess.

5.—Borax bead; O. F. clear yellow glass, colorless on cooling; or, enamel-like on cooling, if present in excess.

NICKEL.

(Use NiSO_4 Solution.)

1.— NaOH precipitates pale green $\text{Ni}(\text{OH})_2$, insoluble in excess and unaltered by boiling.

2.— NH_4OH precipitates pale green $\text{Ni}(\text{OH})_2$, soluble in excess, and in ammonium salts, to a violet-blue solution.

3.— $(\text{NH}_4)_2\text{S}$ precipitates black NiS , insoluble in cold dilute HCl .

4.—Borax bead; O. F. violet when hot, reddish-brown when cold.

COBALT.

(Use $\text{Co}(\text{NO}_3)_2$ Solution.)

1.— NaOH precipitates blue $\text{Co}(\text{OH})_2$, insoluble in excess. On boiling, the precipitate becomes pink.

2.— NH_4OH precipitates blue $\text{Co}(\text{OH})_2$, soluble in excess.

3.— $(\text{NH}_4)_2\text{S}$ precipitates black CoS , insoluble in cold dilute HCl .

4.—Borax bead; O. F. blue.

For the separation of members of this group, see pages 27 and 28.

GROUP II.

Arsenic, As, Antimony, Sb, Mercury (Mercuric) Hg, Bismuth, Bi, Copper, Cu, Cadmium, Cd, Tin, Sn, Gold, Au, Platinum, Pt.

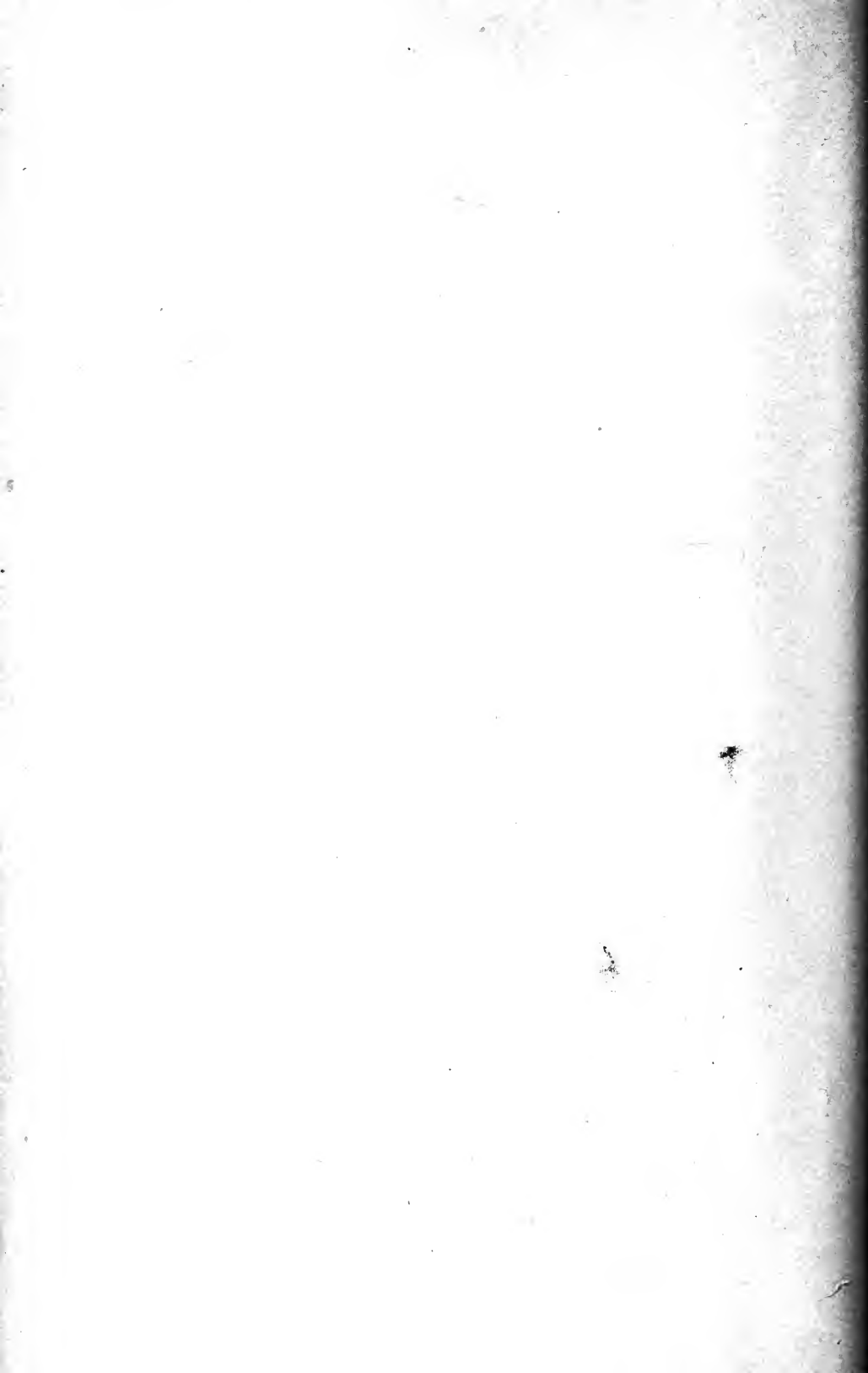
ARSENIC.

ARSENIOUS COMPOUNDS. (Use aqueous solution of As_2O_3 .)

1.—Acidify with hydrochloric acid, and pass H_2S gas through the solution. A precipitate of yellow As_2S_3 is formed, insoluble in hot HCl , soluble in alkalis and in alkaline sulphides and carbonates.

2.—Ammonio-silver nitrate precipitates yellow silver arsenite, Ag_3AsO_3 , soluble in excess of ammonium hydroxide.

3.—Ammonio-cupric sulphate precipitates green copper arsenite, CuHAsO_3 , soluble in excess of ammonium hydroxide.



(Use aqueous solution of Na_2HAsO_3 .)

4.—Test 1, page 20, may be repeated as described. Tests 2 and 3 may be repeated with ordinary solutions of silver nitrate and of copper sulphate.

ARSENIC COMPOUNDS. (Use solution of As_2O_3 .)

1.— H_2S gas precipitates slowly from the acidified solution (acidify with HCl) arsenous sulphide, As_2S_3 , mixed with sulphur.

2.—Ammonio-silver nitrate precipitates brown silver arsenate, Ag_3AsO_4 , soluble in excess of ammonium hydroxide.

3.—Ammonio-cupric sulphate precipitates bluish-green copper arsenate, CuHAsO_4 , soluble in excess of ammonium hydroxide.

(Use solution of Na_2HAsO_4 .)

4.—Test 1 may be repeated as above. Tests 2 and 3 may be repeated with ordinary solutions of silver nitrate and of copper sulphate.

ANTIMONY.

(Use Tartar Emetic in Solution.)

1.—Acidify with HCl and pass H_2S gas, an orange precipitate of Sb_2S_3 is formed. Soluble in sodium hydroxide, in yellow ammonium sulphide, but insoluble in alkaline carbonates.

2.— NaOH , and NH_4OH precipitate antimonous hydroxide, $\text{Sb}(\text{OH})_3$. Soluble in excess of the reagent with NaOH , but not with NH_4OH .

3.— HCl precipitates a white, basic chloride, soluble in excess of the acid.

4.—In the absence of tartaric or citric acids, *e. g.*, in solutions of the chloride, SbCl_3 , an excess of water produces a precipitate of a basic salt, the oxychloride, SbOCl , or "Powder of Algaroth."

5.—Borax bead; O. F. clear yellow when hot, colorless when cold.

See, also, under Special Tests.

MERCURY (IC).

(Use HgCl_2 Solution.)

1.— H_2S gas precipitates black mercuric sulphide, HgS , insoluble in HNO_3 , HCl , or in alkaline sulphides.

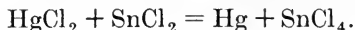
2.— NaOH precipitates yellow mercuric oxide, HgO .

3.— NH_4OH precipitates white mercur-ammonium chloride, NH_2HgCl .

4.— SnCl_2 precipitates white mercurous chloride, Hg_2Cl_2 .



An excess of the reagent precipitates gray metallic mercury.



5.—KI precipitates yellow to scarlet mercuric iodide, HgI_2 soluble in excess.

For Mercurous Compounds, see under Group I., page 24.

See, also, under Special Tests.

BISMUTH.

(Use $\text{Bi}(\text{NO}_3)_3$ Solution.)

1.— H_2S gas precipitates black bismuth sulphide, Bi_2S_3 . Soluble in boiling nitric acid, but insoluble in alkalies and alkaline sulphides.

2.— NaOH and NH_4OH precipitate white bismuth hydroxide, $\text{Bi}(\text{OH})_3$.

3.—KI precipitates brown bismuth iodide, BiI_3 , soluble in excess of the reagent.

4.— H_2O in excess precipitates basic salts of bismuth, bismuth subnitrate, BiONO_3 .

5.—Borax bead; O. F. with small amounts, yellow when hot, colorless when cold. With larger amounts yellow-red when hot, yellow when cold.

COPPER.

(Use CuSO_4 Solution.)

1.— H_2S gas precipitates black cupric sulphide, CuS , soluble in hot nitric acid, practically insoluble in alkalies and in alkaline sulphides.

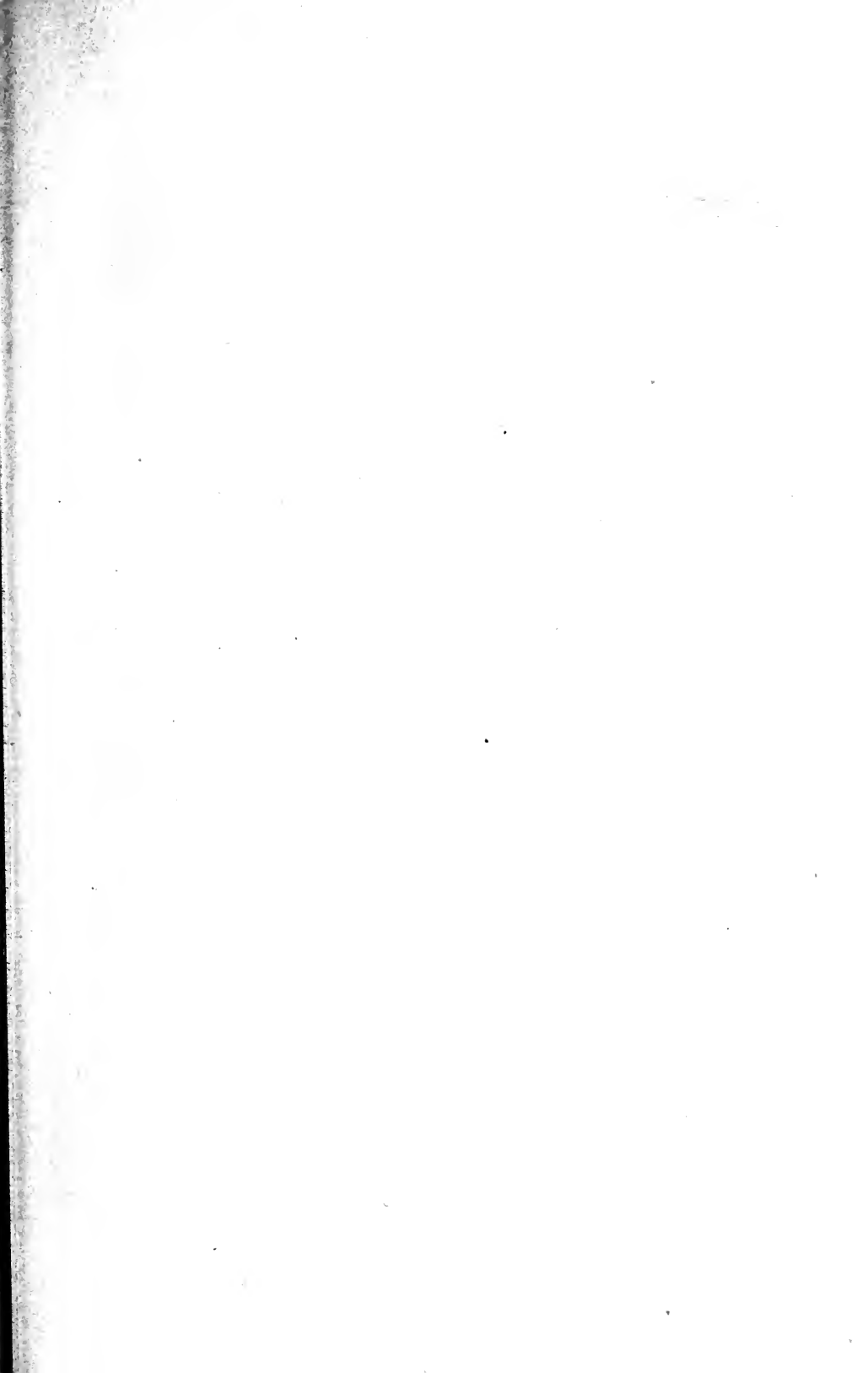
2.— NH_4OH precipitates bluish cupric hydroxide, $\text{Cu}(\text{OH})_2$ soluble in excess, forming a dark blue solution.

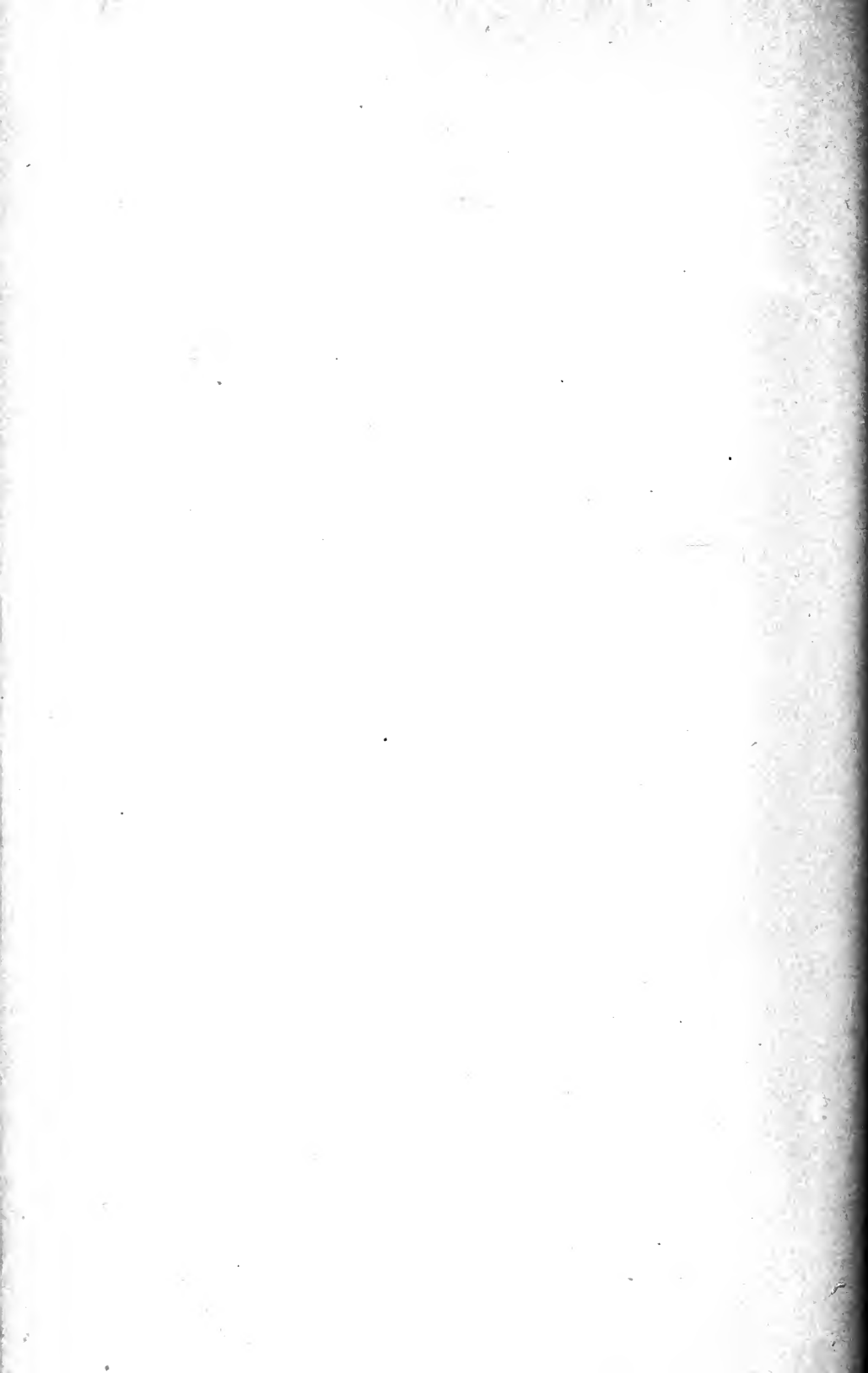
3.— NaOH precipitates blue cupric hydroxide, $\text{Cu}(\text{OH})_2$, insoluble in excess, turning black on boiling.

4.— $\text{K}_4\text{Fe}(\text{CN})_6$ precipitates from neutral or acid solutions, reddish-brown cupric ferrocyanide, $\text{Cu}_2\text{Fe}(\text{CN})_6$.

5. Copper compounds impart a green color to the Bunsen flame.

6.—Borax bead; O. F. green when hot, greenish-blue when cold. R. F. gives a colorless bead, red and opaque on cooling.





CADMIUM.

(Use CdCl_2 Solution.)

- 1.— H_2S precipitates yellow CdS , insoluble in alkaline sulphides, insoluble in KCN , soluble in hot dilute sulphuric acid.
- 2.— NaOH precipitates white $\text{Cd}(\text{OH})_2$, insoluble in excess.
- 3.— NH_4OH precipitates white $\text{Cd}(\text{OH})_2$, soluble in excess.
- 4.— $(\text{NH}_4)_2\text{S}$ precipitates yellow CdS .
- 5.—Borax bead; O. F. clear yellow when hot, colorless when cold.

TIN.

STANNOUS COMPOUNDS. (Use SnCl_2 Solution.)

- 1.— H_2S precipitates brown SnS , soluble in yellow alkaline sulphides, in NaOH , and in boiling HCl .
- 2.— NH_4OH precipitates white H_2SnO_2 , slightly soluble in excess.
- 3.— HgCl_2 precipitates white Hg_2Cl_2 . On boiling, metallic mercury separates out.

STANNIC COMPOUNDS. (Use SnCl_4 Solution.)

- 1.— H_2S precipitates yellowish SnS_2 , soluble in yellow alkaline sulphides, in NaOH , and in boiling HCl .
- 2.— NH_4OH precipitates white H_2SnO_3 , stannic acid, insoluble in excess.
- 3.—Borax head; O. F. Colorless glass with small amounts.

GOLD.

(Use AuCl_3 Solution.)

- 1.— H_2S precipitates black Au_2S_3 (from hot solutions Au_2S) insoluble in HCl or in $(\text{NH}_4)_2\text{CO}_3$, soluble in nitrohydrochloric acid and in yellow ammonium sulphide.
- 2.— $\text{H}_2\text{C}_2\text{O}_4$ or FeSO_4 , boiled with solutions of gold, precipitate the latter in the form of a dark brown powder.
- 3.— SnCl_2 or, better, a mixture of SnCl_2 with Fe_2Cl_6 , precipitates mixed oxides of gold and tin, "Purple of Cassius."
- 4.— NH_4OH precipitates reddish ammonium aurate, "fulminating gold," $\text{Au}_2(\text{NH}_3)_2\text{O}_2$.

PLATINUM.

(Use PtCl_4 Solution.)

- 1.— H_2S precipitates brown PtS_2 , insoluble in HCl or in

$(\text{NH}_4)_2\text{CO}_3$. Soluble in yellow ammonium sulphide, and in nitrohydrochloric acid.

2.—KCl precipitates yellow crystalline K_2PtCl_6 , best after addition of alcohol.

3.— NH_4Cl precipitates yellow crystalline $(\text{NH}_4)_2\text{PtCl}_6$, best after addition of alcohol.

For the separation of members of this group, see p. 25.

GROUP I.

Lead, Pb, Silver, Ag, Mercury (Mercurous), Hg_2 .

LEAD.

(Use $\text{Pb}(\text{NO}_3)_2$ Solution.)

1.—HCl and soluble chlorides precipitate white crystalline lead chloride, PbCl_2 , soluble in hot water.

2.— H_2SO_4 (dil.) precipitates white lead sulphate, PbSO_4 , slightly soluble in water, freely soluble in ammoniacal solutions of ammonium acetate.

3.— K_2CrO_4 precipitates yellow lead chromate, PbCrO_4 , soluble in fixed alkalis.

4.— NH_4OH precipitates white basic lead hydroxide.

5.— H_2S precipitates black lead sulphide, PbS , insoluble in alkalis and alkaline sulphides, but soluble in hot nitric acid.

6.—KI precipitates yellow lead iodide, PbI_2 , soluble in hot water.

7.—Borax bead ; appearance same as with zinc.

SILVER.

(Use AgNO_3 Solution.)

1.—HCl and soluble chlorides precipitate white silver chloride, AgCl , soluble in NH_4OH , insoluble in HNO_3 .

2.—KCN precipitates white AgCN readily soluble in excess.

3.— H_2SO_4 produces no precipitate.

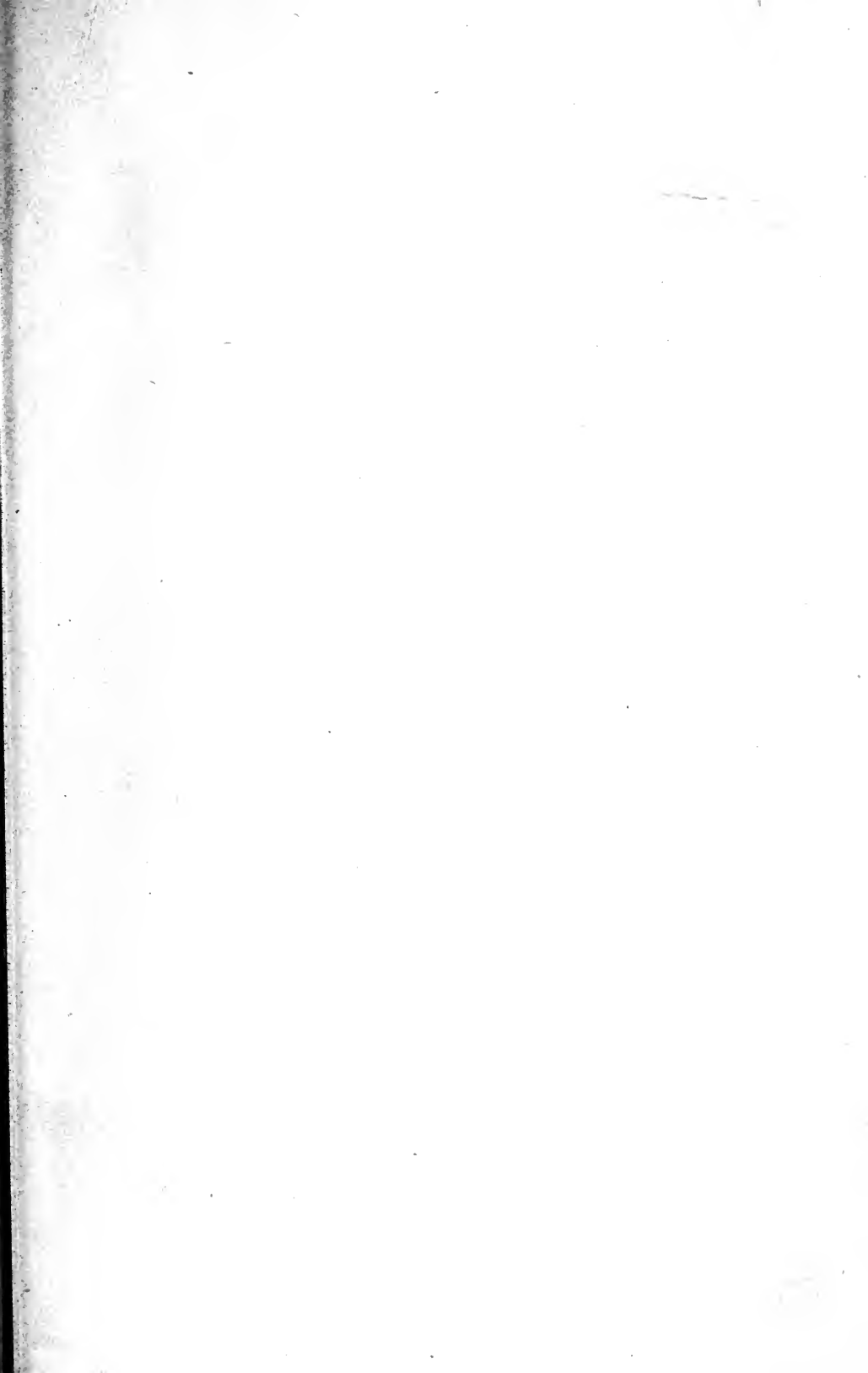
4.— K_2CrO_4 precipitates, from neutral solutions, reddish-brown silver chromate, Ag_2CrO_4 .

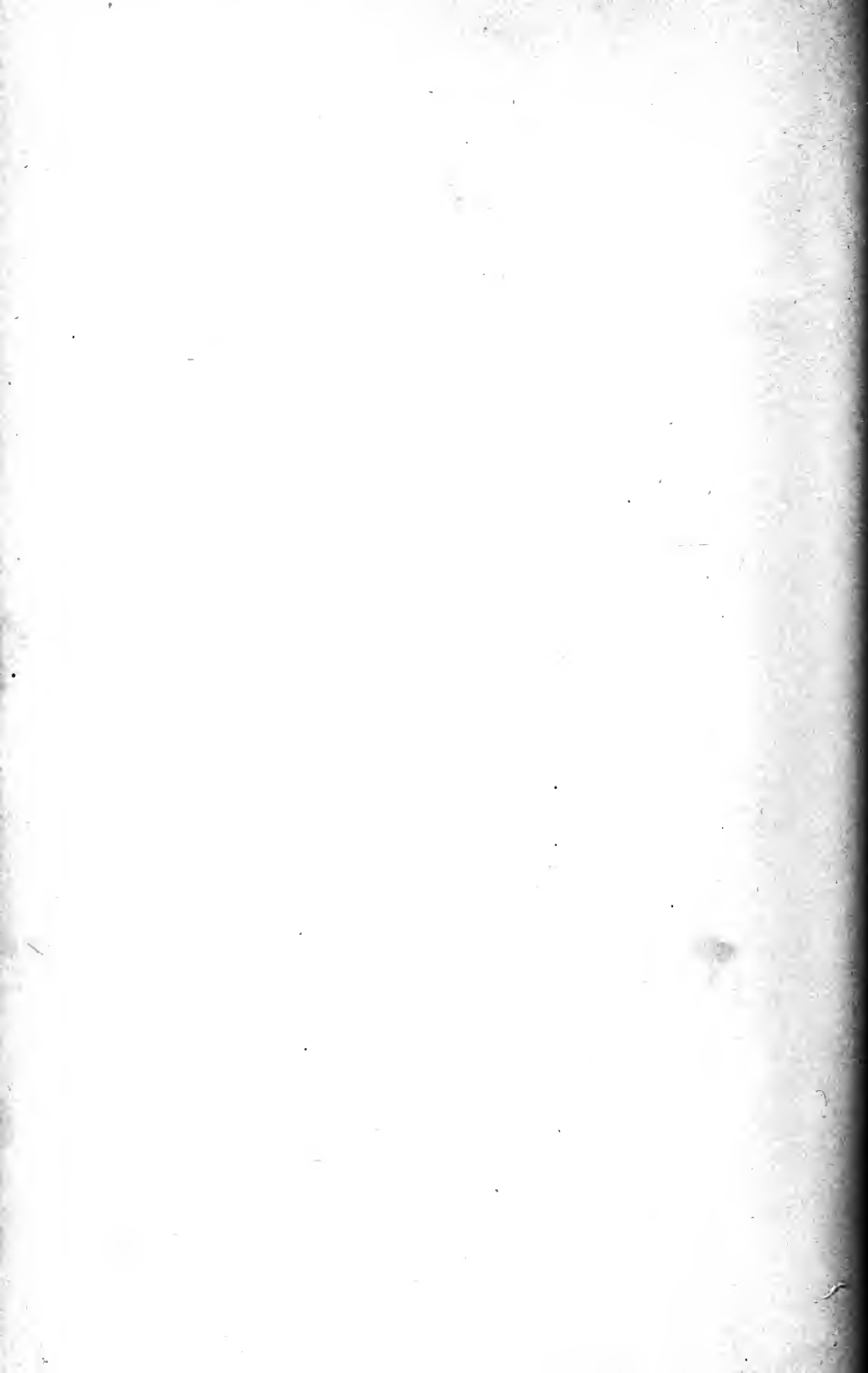
5.— H_2S precipitates black silver sulphide, Ag_2S .

MERCURY(OUS).

(Use $\text{Hg}_2(\text{NO}_3)_2$ Solution.)

1.—HCl precipitates white mercurous chloride, Hg_2Cl_2 , which





turns black on the addition of NH_4OH , mercurous ammonium chloride, $\text{NH}_2\text{Hg}_2\text{Cl}$ being formed.

2.— K_2CrO_4 precipitates orange mercurous chromate, Hg_2CrO_4 .

3.— KI precipitates yellowish-green mercurous iodide, Hg_2I_2 .

4.— H_2S precipitates black mercuric sulphide, HgS , mixed with mercury.

For mercuric compounds, see p. 21. See, also, under Special Tests.

For the separation of the members of this group, see below.

ANALYTICAL SCHEME FOR METALS.*

GROUP I.

To the solution, add dilute HCl , drop by drop, as long as a precipitate is formed.† Filter, and wash the precipitate with cold water. (Reserve the filtrate for Group II.) Perforate the filter paper, wash the precipitate into a test tube and heat to boiling with water. Filter rapidly while the liquid is still hot.

*The Filtrate contains PbCl_2 .
Test for lead with H_2SO_4 or
with K_2CrO_4 . **Pb***

*The Residue contains AgCl and Hg_2Cl_2 .
Wash with hot water. Treat the residue on
the paper with dilute NH_4OH . If it turns
black, mercury, **Hg**, is present.*

Dilute the ammoniacal solution with water, and acidify with HNO_3 . A white precipitate indicates silver, **Ag**.

GROUP II.

Pass H_2S gas through the slightly acid ‡ filtrate from Group I., as long as a precipitate is formed. Filter and *thoroughly wash* the precipitate. (Reserve the filtrate for Group III.) Perforate the filter paper, wash the precipitate into a test tube, add $(\text{NH}_4)_2\text{S}$, warm gently, filter, and wash.

A. The Filtrate contains As, Sb, Sn, Au, Pt.

B. The Precipitate contains Hg, Pb, Bi, Cu, Cd.

A. Acidify the filtrate with dilute HCl . The sulphides, if pres-

* For elementary laboratory practice the analysis may be simplified by omission of Cd, Bi, Sn, Au, Pt, Mn, Ni, and Co. The remaining metals will offer no difficulty.

† The HCl may precipitate antimony and bismuth salts soluble in excess of acid. It is well, therefore, to first test a small part of the solution, trying the effect of acid in excess.

‡ Nitrous, Nitric, and Chloric acids, as well as other oxidizing agents should be absent. If present remove by repeated evaporations with HCl .

ent, are reprecipitated.* Filter, and wash the precipitate. Perforate the filter paper and wash the precipitate into a large test-tube. Add some fragments of solid $(\text{NH}_4)_2\text{CO}_3$ and warm for several minutes. Filter and wash.

Dissolve the *Residue* in hot HCl, dilute with water, and pass H_2S gas. An orange-red precipitate = Sb_2S_3 .
Sb

Acidify the *Filtrate* with dilute HCl. A yellow precipitate = As_2S_3 . **As**
Apply Special Tests to the original solution.

In this process, tin, gold, and platinum, if present, will be found in the residue with antimony. If it be desired to detect and separate these metals, boil the precipitate with strong HCl, and filter. A remaining residue will be gold or platinum. Dissolve this in nitrohydrochloric acid and test the solution with SnCl_2 for gold, **Au**, with KCl for platinum, **Pt**. (See p. 23.)

The solution obtained above with boiling HCl is then diluted, and boiled in a dish with a piece of platinum foil and a fragment of zinc. Antimony, **Sb**, will be deposited as a coating on the platinum, from which it may be dissolved in HNO_3 and further tested. The tin, **Sn**, will separate as a spongy sediment, which may then be dissolved in HCl and tested with HgCl_2 . (See p. 23.)

B. The precipitate containing Hg, Pb, Bi, Cu, and Cd. Perforate the filter paper, wash the precipitate into a beaker, add strong HNO_3 , boil for several minutes, and filter.

A Black Residue = HgS . **Hg**

Transfer the residue to a porcelain dish, dissolve in $\text{HCl} + \text{HNO}_3$. Boil off the excess of acid, dilute with a little water and test for mercury with NaOH, see p. 21.

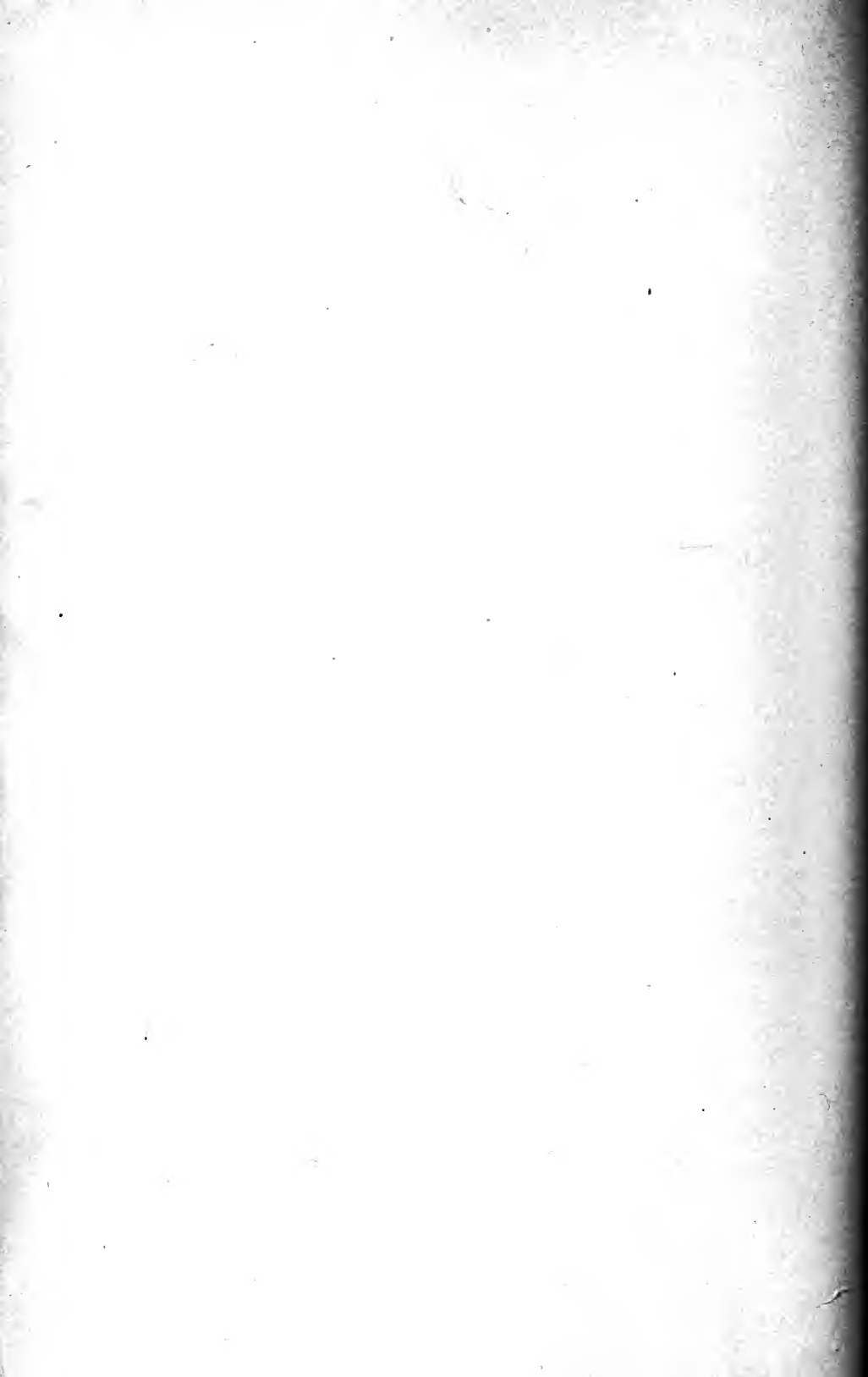
The Filtrate contains Pb, Bi, Cu, Cd. Boil off the excess of acid, add a little water, and then, if lead be present, a few drops of dilute H_2SO_4 .† A precipitate = PbSO_4 . **Pb**

Filter and add NH_4OH to the filtrate. A white flocculent precipitate indicates bismuth, **Bi**, filter and apply tests. If the NH_4OH in excess produces a dark blue color, then copper, **Cu**, is present. To test for cadmium, **Cd**, copper being absent, concentrate the ammoniacal solution and pass H_2S gas. A yellow precipitate = CdS . If copper be present, add KCN until the blue color is discharged, and then pass H_2S gas. Cadmium will be precipitated as yellow CdS .

The method to be used for Group III. will be decided by the presence or absence of phosphoric acid. Organic acids, *e. g.*, tartaric acid, citric acid, etc., should be absent in any case, and, if

* A fine, yellowish-white precipitate here may result from decomposition of the ammonium sulphide by the acid.

† If lead was not found in Group I., test, first, only a portion of the solution with the dilute sulphuric acid, then, if lead be found, add the acid to the rest of the solution, filter, and proceed as above.



present, should be destroyed by evaporation of the solution to dryness and ignition of the residue. The ignited residue is then dissolved in water and hydrochloric acid, and the analysis proceeded with.

To test for phosphoric acid, dissolve a portion of the precipitate obtained on addition of NH_4Cl and NH_4OH (see scheme below) in dilute HNO_3 , and add two volumes of ammonium molybdate solution. A yellow precipitate indicates presence of phosphoric acid.

GROUP III. (PHOSPHATES ABSENT.)

Boil the filtrate from Group II. *until all H_2S is expelled*, add a few drops of strong HNO_3 and again heat to boiling.* Add NH_4Cl and NH_4OH . If there be a precipitate, filter. (The filtrate (A) is to be reserved for the ammonium sulphide test.) Wash the precipitate, then perforate the paper and wash the precipitate into a test-tube, add NaOH and boil for several minutes. Filter, and wash.

Test a portion of the Precipitate for Chromium, Cr , by tests 4 and 5 (p. 18). Dissolve the remainder of the precipitate in dilute HCl and test for iron, Fe , with KCNS .	To the Filtrate add enough HCl to render it faintly acid, and then add $(\text{NH}_4)_2\text{CO}_3$. A precipitate indicates aluminum, Al .
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To the filtrate (A) (reserved above) add $(\text{NH}_4)_2\text{S}$.† If a precipitate be obtained, filter, and wash. (Reserve this filtrate for Group IV.) Treat the precipitate on the paper with cold dilute HCl . A black residue‡ should be tested for nickel, **Ni**, and cobalt, **Co**, by the borax bead, see p. 20.

The hydrochloric acid solution is then boiled. Cool, add a large excess of NaOH and, after shaking well, filter.

* The nitric acid is added and the solution boiled for the purpose of oxidizing iron; an excess of the acid, however, should be avoided, as should also prolonged boiling, otherwise manganic hydroxide may be precipitated on the subsequent addition of the ammonium hydroxide.

† In absence of Mn , Ni , and Co , a grayish-white precipitate obtained on addition of $(\text{NH}_4)_2\text{S}$ is sufficient indication of the presence of Zinc.

‡ This residue may be dissolved in aqua regia, the excess of acid removed by boiling, the solution nearly neutralized with Na_2CO_3 , and KCN added until the precipitated cyanides are just redissolved. Add NaOH and then bromine water until the solution is colored. A precipitate indicates Nickel, the solution may be tested for Cobalt.

Test the <i>Precipitate</i> for manganese, Mn , by test 3, p. 19.	To the <i>Filtrate</i> add $(\text{NH}_4)_2\text{S}$. A precipitate indicates Zinc, Zn .
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GROUP III. (PHOSPHATES PRESENT.)

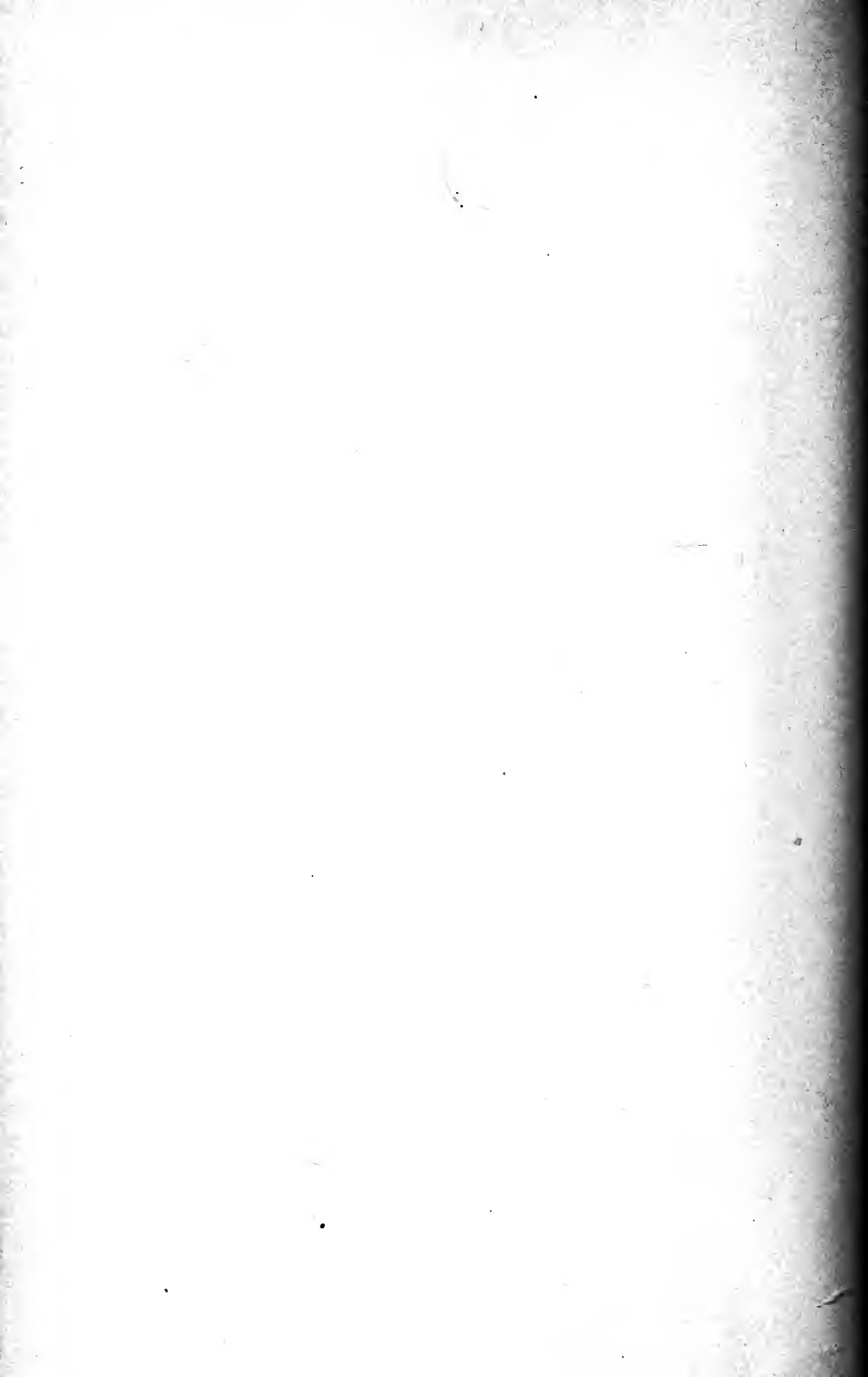
Boil the filtrate from Group II. until all H_2S is expelled, add a few drops of strong HNO_3 and again heat to boiling. Add NH_4Cl and NH_4OH , and filter. (Reserve the filtrate for Group IV.) To the filtrate add $(\text{NH}_4)_2\text{S}$ and filter. Wash the two precipitates and then digest them together in a dish with $(\text{NH}_4)_2\text{S}$. Filter and wash. Dissolve the precipitate in hot dilute HCl , with addition of a small crystal of KClO_3 . Drive off the chlorine by heat and filter off any separated sulphur. Nearly neutralize the solution by adding dilute sodium carbonate, and then add an acetic acid solution of sodium acetate. Warm, and filter immediately.

The <i>Precipitate</i> is boiled with NaOH for several minutes, and tested for Fe , Cr , and Al , as described in the last scheme, in absence of phosphates.	To the <i>Filtrate</i> add Fe_2Cl_6 drop by drop, as long as a precipitate forms. Warm for some time, and filter. To the filtrate add NH_4Cl and NH_4OH , and proceed with the analysis as described in the last scheme, phosphates being absent. Test for Cr , Al , Ni , Co , Mn , and Zn , and reserve, as described, the filtrate from the first ammonium sulphide precipitation for Group IV.
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GROUP IV.

To the filtrate from Group III., add HCl , boil and filter. To the filtrate add NH_4OH and $(\text{NH}_4)_2\text{CO}_3$, warm and filter. (Test the filtrate for magnesium, **Mg**, with Na_2HPO_4 .) Dissolve the precipitate in a little HCl , evaporate the solution to dryness and treat the residue with absolute alcohol.

<i>Residue</i> = BaCl_2 . Dissolve in water, and test for barium, Ba .	Evaporate the <i>Solution</i> , to expel the alcohol, and convert the chlorides to nitrates by repeated evaporations with HNO_3 . Evaporate finally to dryness, and treat the residue with absolute alcohol.		
	<table> <tr> <td><i>Residue</i> = $\text{Sr}(\text{NO}_3)_2$. Dissolve in water and test for strontium, Sr.</td><td><i>Solution</i> contains $\text{Ca}(\text{NO}_3)_2$. Test for calcium, Ca.</td></tr> </table>	<i>Residue</i> = $\text{Sr}(\text{NO}_3)_2$. Dissolve in water and test for strontium, Sr .	<i>Solution</i> contains $\text{Ca}(\text{NO}_3)_2$. Test for calcium, Ca .
<i>Residue</i> = $\text{Sr}(\text{NO}_3)_2$. Dissolve in water and test for strontium, Sr .	<i>Solution</i> contains $\text{Ca}(\text{NO}_3)_2$. Test for calcium, Ca .		



ALTERNATIVE METHOD. GROUP IV.

To the filtrate from Group III. add NH_4Cl , $(\text{NH}_4)_2\text{CO}_3$ and NH_4OH . Warm the mixture for some time. Filter. (Test the filtrate for magnesium, **Mg**, with Na_2HPO_4 .) Dissolve the precipitated carbonates in dilute acetic acid, and test a portion of the solution with $\text{K}_2\text{Cr}_2\text{O}_7$ for barium. If a precipitate be obtained, add the reagent to the rest of the solution and filter.

<i>Precipitate</i> = Barium,	To a portion of the <i>Filtrate</i> add a solution of CaSO_4 .
Ba.	If a precipitate be obtained (the precipitate may form slowly) strontium, Sr , is present; add to the rest of the filtrate a strong solution of $(\text{NH}_4)_2\text{SO}_4$ boil, filter and test the filtrate for calcium, Ca , with $(\text{NH}_4)_2\text{C}_2\text{O}_4$ and NH_4OH . If strontium is not present, omit the addition of $(\text{NH}_4)_2\text{SO}_4$, and test the remainder of the filtrate at once for calcium.

GROUP V.

Test the original solution for Ammonium, **NH₄**. (See p. 15.) For Potassium, Sodium, and Lithium, use the flame tests with the original solution, *or*, evaporate the solution containing only members of this group, and heat strongly. Dissolve the residue in a little water, add a few drops of HCl , filter if necessary, add alcohol and an excess of PtCl_4 . A precipitate = K_2PtCl_6 , **K**. Add a little water, filter and test the filtrate for sodium by the flame test, and with potassium pyroantimonate. A precipitate = $\text{H}_2\text{Na}_2\text{Sb}_2\text{O}_7$, **Na**.

When lithium is to be tested for, it is preferable to precipitate the magnesium in Group IV. with $(\text{NH}_4)_2\text{HPO}_4$, then to filter, and to the filtrate to add Na_2HPO_4 and NaOH . Finally concentrate by boiling—a precipitate indicates lithium, **Li**.

EXAMINATION OF A NEUTRAL OR SLIGHTLY ACID SOLUTION
CONTAINING BUT ONE METAL.

1.—Add dilute HCl . Precipitate: Soluble on heating with water = **Pb**. Insoluble in water, add NH_4OH ; it turns black = **Hg(ous)**; it dissolves = **Ag**.

2.—Pass H_2S through the slightly acid solution. Precipitate: Soluble in $(\text{NH}_4)_2\text{S}$ —yellowish = **As**, **Sn(ic)**; orange = **Sb**; black, or brownish-black = **Sn(ous)**, **Au**, **Pt**. Insoluble in $(\text{NH}_4)_2\text{S}$ —yellow = **Cd**; black = **Cu**, **Hg(ic)**, **Pb**, **Bi**.

3.—Add NH_4Cl and NH_4OH to original solution. Precipitate: Reddish-brown = **Fe**(ic); greenish = **Cr**, (**Fe**(ous)); white = **Al**.

If *phosphates are present*, add, to the original, NH_4OH , and then $\text{HC}_2\text{H}_3\text{O}_2$ to acid reaction. Boil the mixture.

(a) A precipitate forms—filter, wash into a test-tube, add NaOH , and boil. Reddish residue = **Fe**. Greenish residue = **Cr**. No residue, but a precipitate is obtained by boiling with NH_4Cl = **Al**.

(b) No precipitate forms—test with K_2CrO_4 , a ppt. = **Ba**. Add dilute H_2SO_4 , a ppt. = **Sr**. Add $(\text{NH}_4)_2\text{C}_2\text{O}_4$, a ppt. = **Ca**. Cool, add excess of NH_4OH , a ppt. = **Mg**, or **Mn**. Test the precipitate for **Mn** by test 3 (p. 19).

If *organic acids are present*, these must be destroyed before testing under 3. Evaporate the solution to dryness, ignite the residue, and redissolve in water acidulated with HCl .

4.—To solution not precipitated by NH_4Cl and NH_4OH , add $(\text{NH}_4)_2\text{S}$. Precipitate: Flesh-tint = **Mn**; dirty-white = **Zn**; black = **Ni**, **Co** (insoluble in cold dilute HCl).

5.—Add $(\text{NH}_4)_2\text{CO}_3$, or, to original solution add NH_4Cl , $(\text{NH}_4)_2\text{CO}_3$ and NH_4OH . Precipitate = **Ba**, **Sr**, **Ca**. Filter, dissolve in dilute $\text{HC}_2\text{H}_3\text{O}_2$, and divide this solution into 2 parts.

(a) Add solution of CaSO_4 . Precipitate: **Ba** (ppt. forms at once), **Sr** (ppt. forms slowly).

(b) If a precipitate was obtained in *a*, add $\text{K}_2\text{Cr}_2\text{O}_7$. Precipitate = **Ba**. No precipitate is formed with $\text{K}_2\text{Cr}_2\text{O}_7$ = **Sr**.

(c) No precipitate was obtained in *a*, add $(\text{NH}_4)_2\text{C}_2\text{O}_4$ and NH_4OH . Precipitate = **Ca**.

6.—If $(\text{NH}_4)_2\text{CO}_3$ gave no precipitate, add Na_2HPO_4 . Precipitate = **Mg**.

7.—No precipitate having been obtained by any of the preceding reagents, test the original for **Li**, **Na**, and **K**, by the flame, and for **NH**₄, by heating with a fixed alkali. (See p. 16.)

The metal having been determined, the examination for the combined acid radical may be conducted according to paragraphs 1, 2, 4, 5, 8, and 9, under General Plan of Analysis. (See p. 36.)

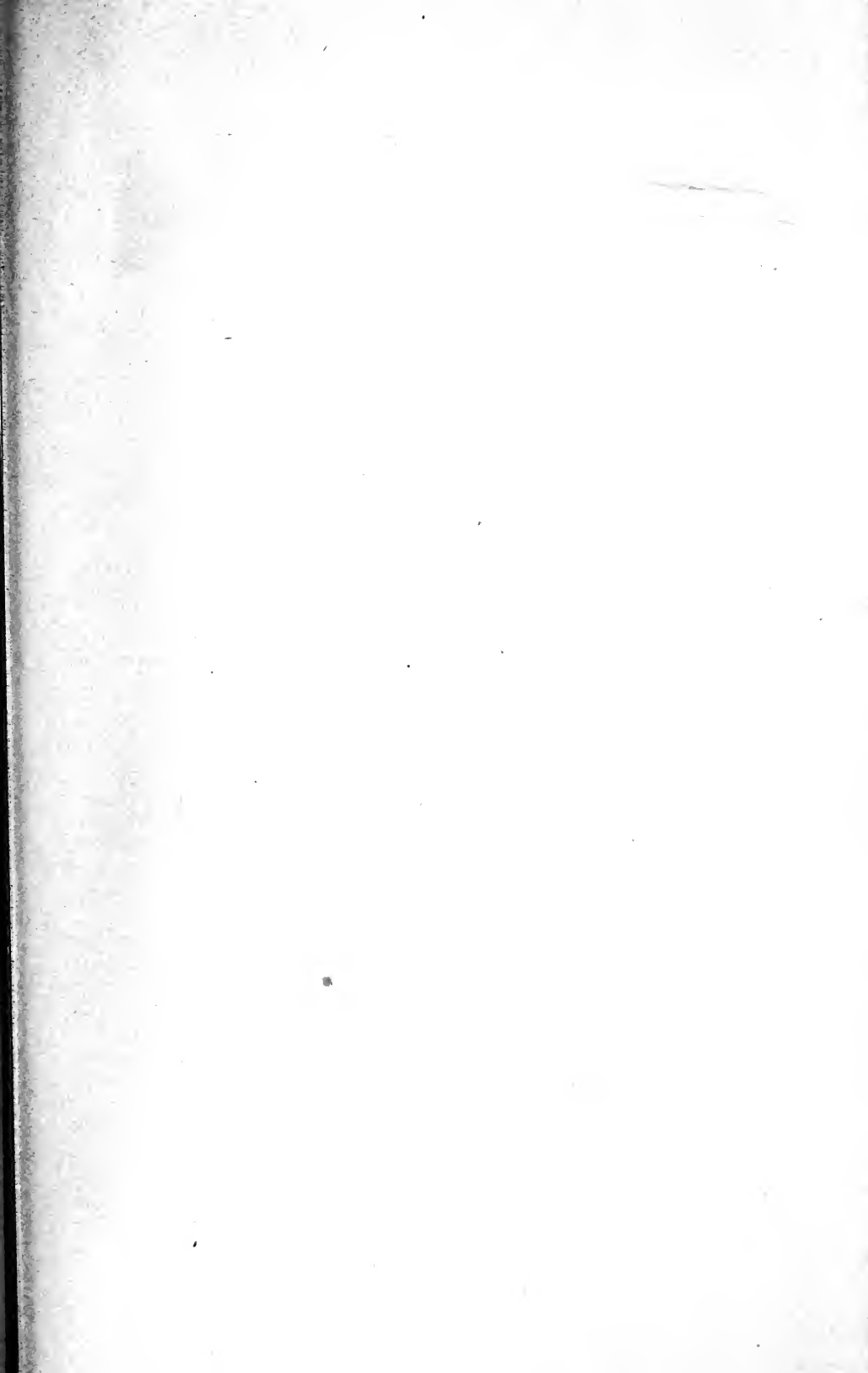
TESTS FOR THE COMMON ACIDS.

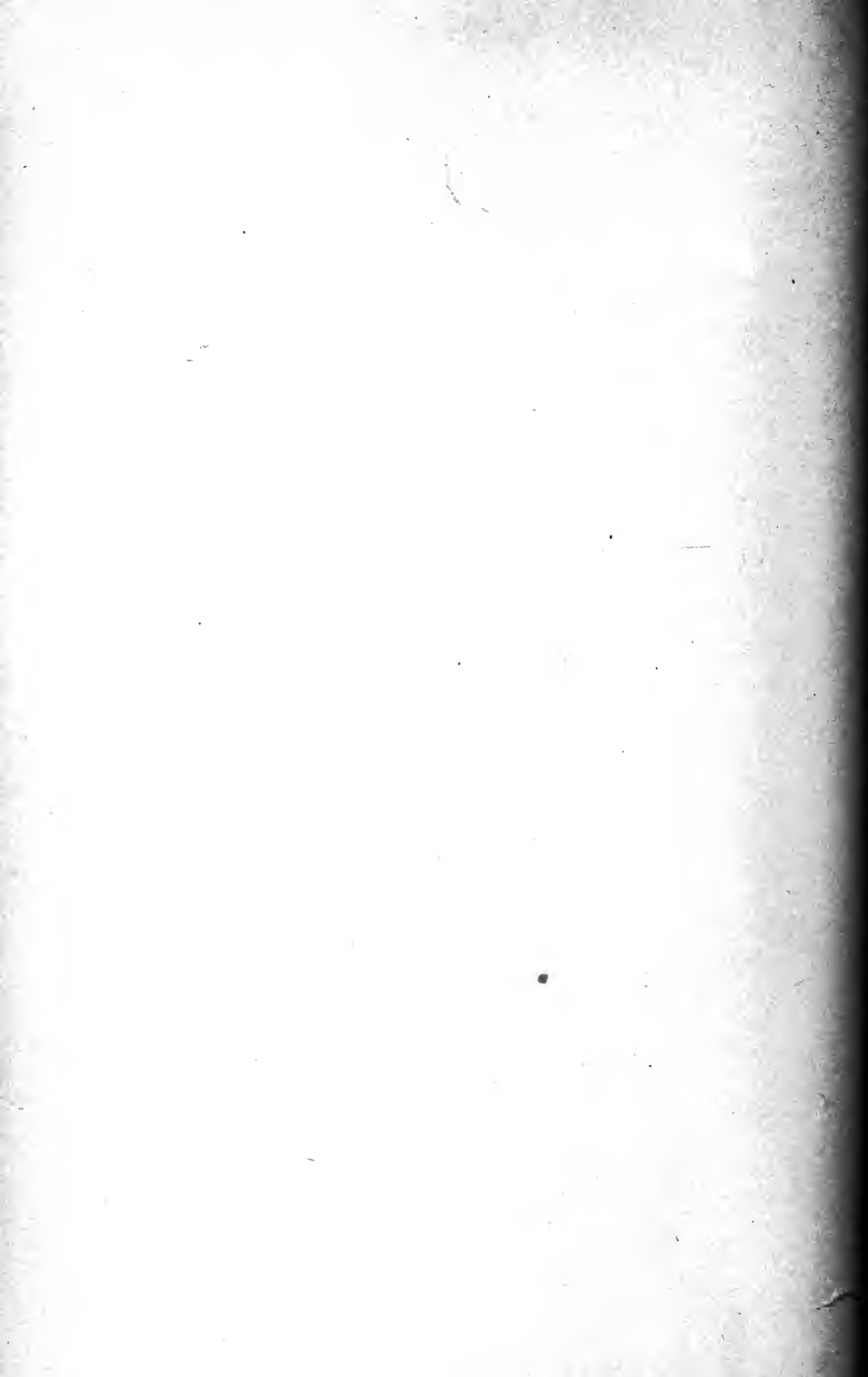
HYDROCHLORIC ACID, HCl , AND CHLORIDES.

1.— AgNO_3 precipitates curdy white silver chloride, AgCl , soluble in NH_4OH , insoluble in HNO_3 .

2.— $\text{Hg}_2(\text{NO}_3)_2$ precipitates white mercurous chloride, Hg_2Cl_2 .

3.— $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ precipitates white crystalline lead chloride, PbCl_2 , soluble in hot water.





4.— H_2SO_4 and MnO_2 warmed with the solution, liberate chlorine gas.

5.—Warmed with H_2SO_4 , chlorides give off colorless fumes of HCl .

Chlorates: 1.—Warmed with H_2SO_4 chlorates give off yellowish-green fumes of Cl_2O_4 . 2.— AgNO_3 gives no precipitate. 3.—Heated on charcoal, chlorates deflagrate.

Hypochlorites: 1.—Solutions bleach litmus. 2.—With AgNO_3 a precipitate of AgCl is slowly formed. 3.—Warmed with H_2SO_4 , Cl gas is given off.

NITRIC ACID, HNO_3 , AND NITRATES.

1.—If strong HNO_3 be boiled with copper filings, the acid is decomposed, red fumes of NO_2 are produced, and the liquid becomes green.

2.—Add an equal bulk of strong H_2SO_4 . Cool the mixture and float over it a solution of FeSO_4 . At the contact of the two liquids a brown ring will develop.

3.—A small quantity of the fluid added to a solution of *brucia* in concentrated H_2SO_4 , develops a fine red color. (Chloric acid gives the same reaction.)

4.—Nitrates and nitric acid are reduced by a mixture of zinc and H_2SO_4 , NH_3 being formed.

Nitrites: 1.—Warmed with H_2SO_4 red fumes are given off. (A nitrate so treated yields nearly colorless fumes.) 2.—Nitrous acid, and nitrites in presence of sulphuric acid, give a blue color with KI and starch paste. 3.—Floated over a solution of FeSO_4 , a brown ring will form at the contact.

SULPHURIC ACID, H_2SO_4 , AND SULPHATES.

1.— BaCl_2 precipitates white barium sulphate, BaSO_4 , insoluble in boiling water or in hydrochloric acid.

2.— $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ precipitates white lead sulphate, PbSO_4 , soluble only in hot concentrated acids.

Sulphides: 1.—Warmed with H_2SO_4 , if acted upon at all, give off H_2S . 2.—Insoluble sulphides are decomposed by HNO_3 with separation of sulphur.

Sulphites: 1.—Warmed with H_2SO_4 , yield H_2S and SO_2 . 2.—Sulphites decompose AgNO_3 with separation of Ag . Sulphurous acid first reddens, then bleaches litmus paper.

Thiosulphates (Hypsulphites): 1.—Warmed with H_2SO_4 yield H_2S , SO_2 , and sulphur. 2.— AgNO_3 is decomposed with final precipitation of Ag_2S .

BORIC ACID, H_3BO_3 , AND BORATES.

1.—Solutions of the crystalline acid in glycerine burn with a green flame.

2.—Solutions of the acid turn litmus paper red. Tumeric paper is at first unchanged, but on drying becomes reddish-brown. A drop of ammonium hydroxide placed on the dried tumeric paper gives a bluish-black spot.

Sodium tetraborate, $Na_2B_4O_7$, "Borax:" Burns with the yellow flame of sodium, and has an alkaline reaction with litmus paper. The green boric acid flame can be obtained by mixing the borax with a few drops of H_2SO_4 and a little alcohol. Upon ignition the alcohol will burn with a green mantle. A concentrated solution of borax warmed with $CaCl_2$ and a little NH_4OH , gives a precipitate of calcium borate, soluble in $HC_2H_3O_2$ and in excess of water.

CHROMIC ACID, H_2CrO_4 , AND CHROMATES.

1.— H_2S gas, in acid solutions, produces a green color, due to formation of a chromic compound, and sulphur is precipitated.

2.— $AgNO_3$ precipitates dark red Ag_2CrO_4 , soluble in nitric acid and in ammonium hydroxide.

3.—Treated with an excess of H_2SO_4 and shaken with an ethereal solution of H_2O_2 , a fine blue color is produced.

4.— $Hg_2(NO_3)_2$ precipitates dark red Hg_2CrO_4 .

Dichromates (of alkali metals), *e. g.*, $K_2Cr_2O_7$. Tests are similar to those above. Test 3 is best performed as follows: To water in a test tube add a few drops of H_2O_2 , acidify with one or two drops of HCl , add a little ether and then one or two drops of the dichromate. The ethereal layer is colored blue.

HYDROBROMIC ACID, HBr , AND BROMIDES.

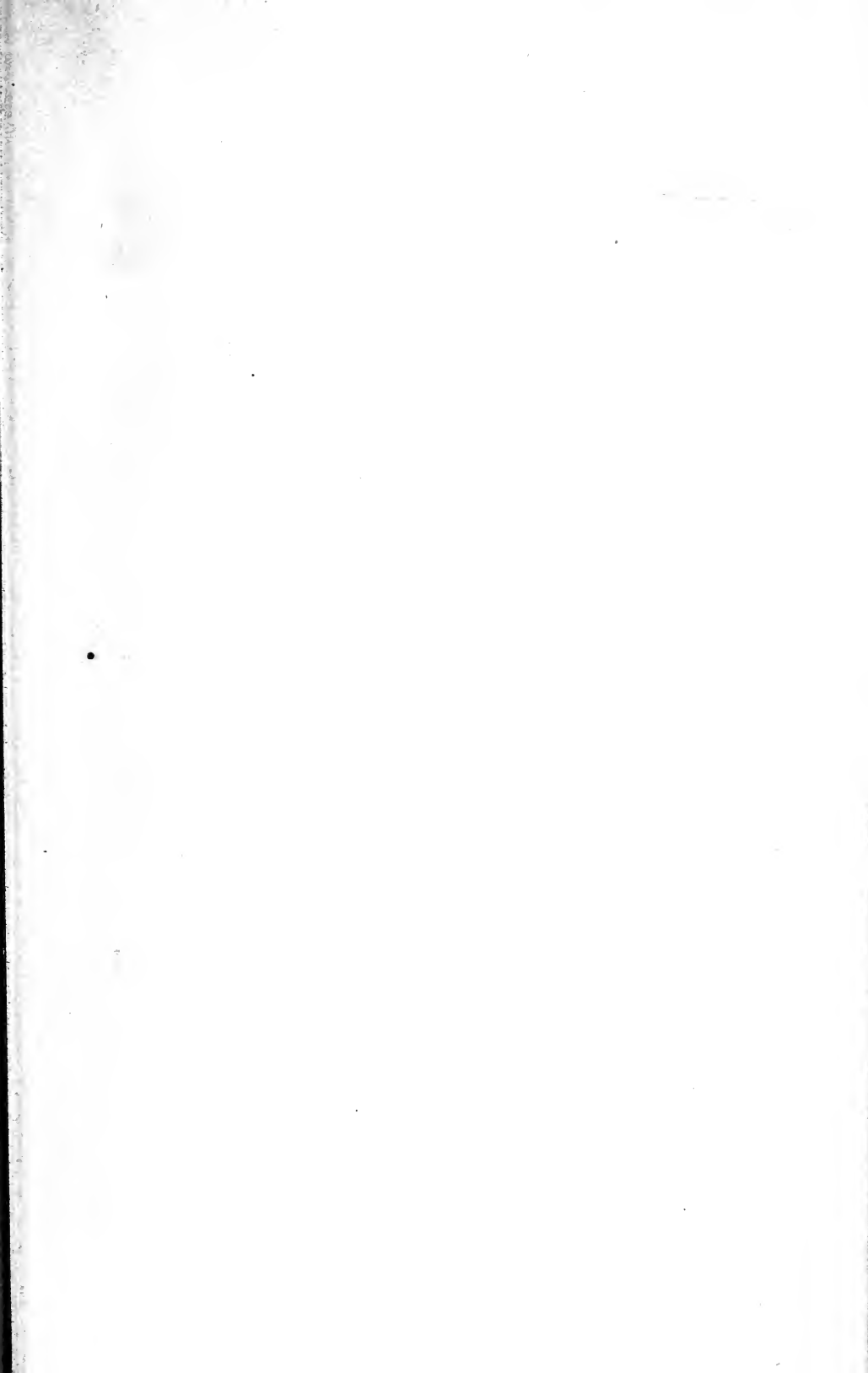
1.— $AgNO_3$ precipitates yellowish-white silver bromide, $AgBr$, insoluble in nitric acid, slowly soluble in strong, insoluble in dilute ammonium hydroxide.

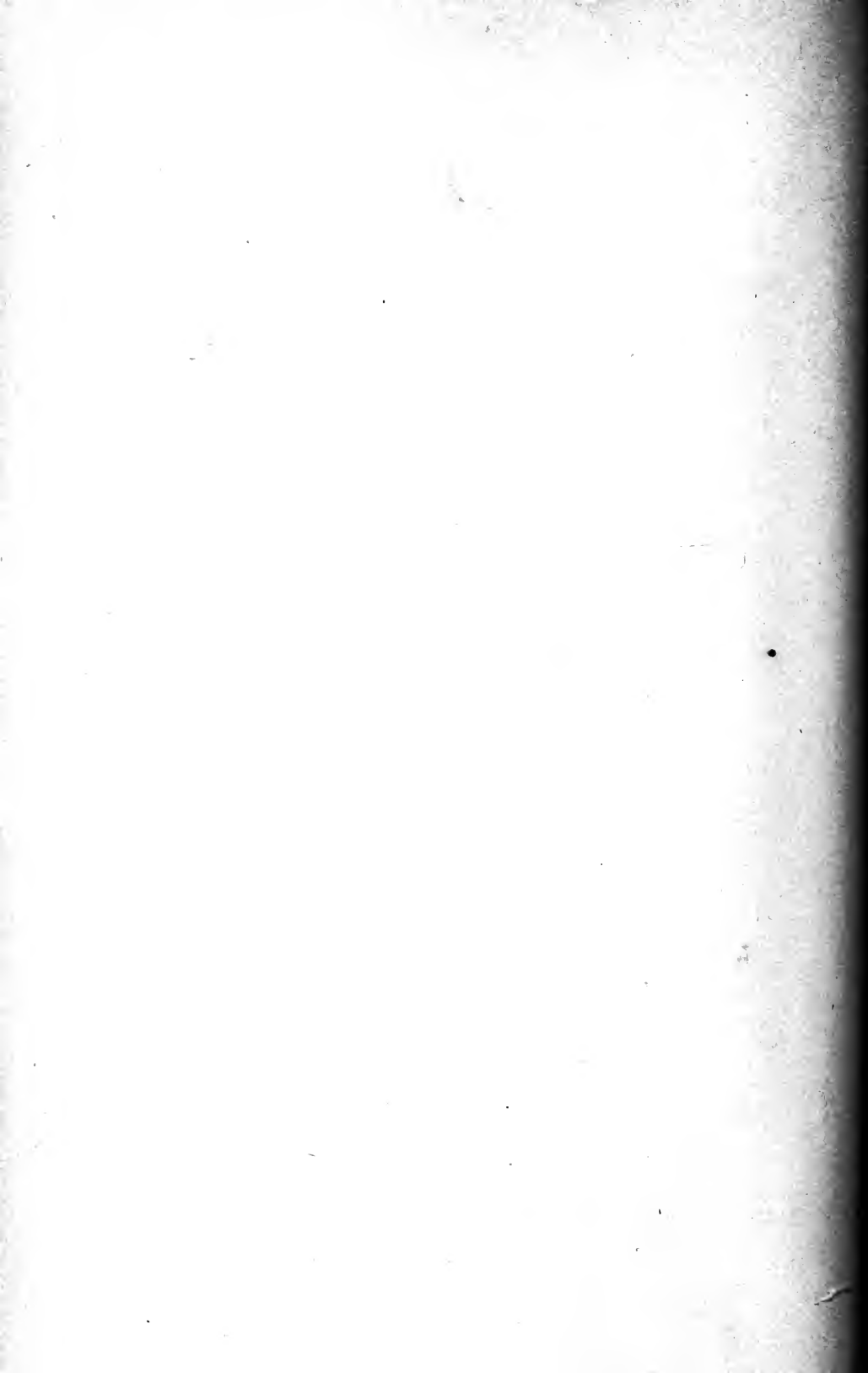
2.— $Hg_2(NO_3)_2$ precipitates yellow mercurous bromide, Hg_2Br_2 .

3.—Add a little carbon disulphide, CS_2 , and then a few drops of chlorine water. Mix well by shaking. The CS_2 acquires a reddish-yellow tint. (With iodides by the same test, the carbon disulphide is colored violet-red.)

4.—With starch paste and chlorine water a yellow color is developed.

5.—Warmed with H_2SO_4 , brown fumes of bromine are evolved.





HYDROCYANIC ACID, HCN, AND CYANIDES.

- 1.—Note the characteristic odor.
- 2.— AgNO_3 precipitates white silver cyanide, AgCN , soluble in KCN , soluble in NH_4OH , and in boiling HNO_3 , but insoluble in cold dilute HNO_3 . To obtain the reaction with cyanides, such as KCN , add first a little HNO_3 to decompose the cyanide and then add the AgNO_3 . The precipitation is distinguished from AgCl by its solubility in boiling HNO_3 , and by the odor of HCN developed on warming with HCl .
- 3.—Add a few drops of yellow ammonium sulphide and evaporate to dryness on the water-bath. To the residue add a drop of Fe_2Cl_6 . A blood-red color is produced, or, if the black sulphide of iron forms, dissolve this in a drop of dil. HCl , and the red color will then become apparent.
- 4.—Add NaOH and a few drops of a solution of FeSO_4 which has been previously exposed to the air, warm gently, and acidify with HCl . Prussian blue will be formed if HCN be present.
- 5.—Add a few drops of picric acid to a solution of potassium cyanide, and warm. Dark red potassium isopurpurate is formed.

HYDRIODIC ACID, HI , AND IODIDES.

- 1.— AgNO_3 precipitates yellow silver iodide, AgI , insoluble in HNO_3 or in NH_4OH .
- 2.— $\text{Hg}_2(\text{NO}_3)_2$ precipitates green mercurous iodide, Hg_2I_2 .
- 3.— HgCl_2 precipitates red mercuric iodide, HgI_2 .
- 4.—Add a few drops of "Chlorine water," and then a little starch paste. A blue color is developed which disappears when the solution is heated, but reappears when the solution is cooled. For free iodine the same test is used without the addition of chlorine water.
- 5.—Warmed with H_2SO_4 violet fumes of iodine are given off.

PERMANGANIC ACID, $\text{H}_2\text{Mn}_2\text{O}_8$, AND PERMANGANATES.

- 1.—Heated in a dry tube permanganates decrepitate with evolution of oxygen.
- 2.—Permanganates dissolve in water to a purple-red solution.
- 3.—Acidulate the aqueous solution with H_2SO_4 and pass H_2S gas. The solution is decolorized and sulphur precipitated.

Manganates (salts of H_2MnO_4 , green in color), and *Permanganates* are decom-

posed by boiling with HCl. Chlorine gas is given off and a permanent manganous salt is produced. See tests on p. 19.

PHOSPHORIC ACID, H_3PO_4 , AND ORTHOPHOSPHATES.

1.—Neutral Fe_2Cl_6 with $\text{NaC}_2\text{H}_3\text{O}_2$ precipitates yellowish-white ferric phosphate, $\text{Fe}_2(\text{PO}_4)_2$. Free mineral acids should be absent. For the preparation of neutral ferric chloride, see Appendix.

2.— CaCl_2 precipitates, from solutions of soluble phosphates, white calcium hydrogen phosphate, CaHPO_4 , soluble in acetic acid. Solutions of the free acid are precipitated only after neutralization.

3.— AgNO_3 precipitates yellow silver phosphate, Ag_3PO_4 , soluble in acetic acid and in ammonium hydroxide.

4.—Acidify with nitric acid and add ammonium molybdate $(\text{NH}_4)_2\text{MoO}_4$, a yellow precipitate of ammonium phosphomolybdate, $(\text{NH}_4)_3\text{PO}_4(\text{MoO}_3)_{10} \cdot 2\text{H}_2\text{O}$, is obtained. Soluble in ammonium hydroxide.

5.—“Magnesia Mixture” precipitates white magnesium ammonium phosphate, $\text{Mg}(\text{NH}_4)\text{PO}_4$, soluble in all acids.

Phosphites: 1.—Warmed with AgNO_3 in presence of NH_4OH , metallic silver is separated. 2.— CaCl_2 gives a white precipitate. 3.—Magnesia mixture gives a precipitate from strong solutions.

Hypophosphites: 1.—On ignition inflammable PH_3 is given off. 2.— AgNO_3 precipitates white silver hypophosphite, turning black on exposure. 3.— $(\text{NH}_4)_2\text{MoO}_4$ gives a blue precipitate. 4.— CaCl_2 gives no precipitate.

Pyrophosphates: 1.— AgNO_3 precipitates white silver pyrophosphate. 2.— MgSO_4 precipitates magnesium pyrophosphate, soluble in excess of the reagent. 3.— $(\text{NH}_4)_2\text{MoO}_4$ reacts very slowly, or not at all.

Metaphosphates: 1.— AgNO_3 precipitates white silver metaphosphate. 2.— $(\text{NH}_4)_2\text{MoO}_4$ causes no precipitate. 3.—Albumen forms a white precipitate.

ACETIC ACID, $\text{HC}_2\text{H}_3\text{O}_2$, AND ACETATES.

1.—Note the characteristic odor of the acid.

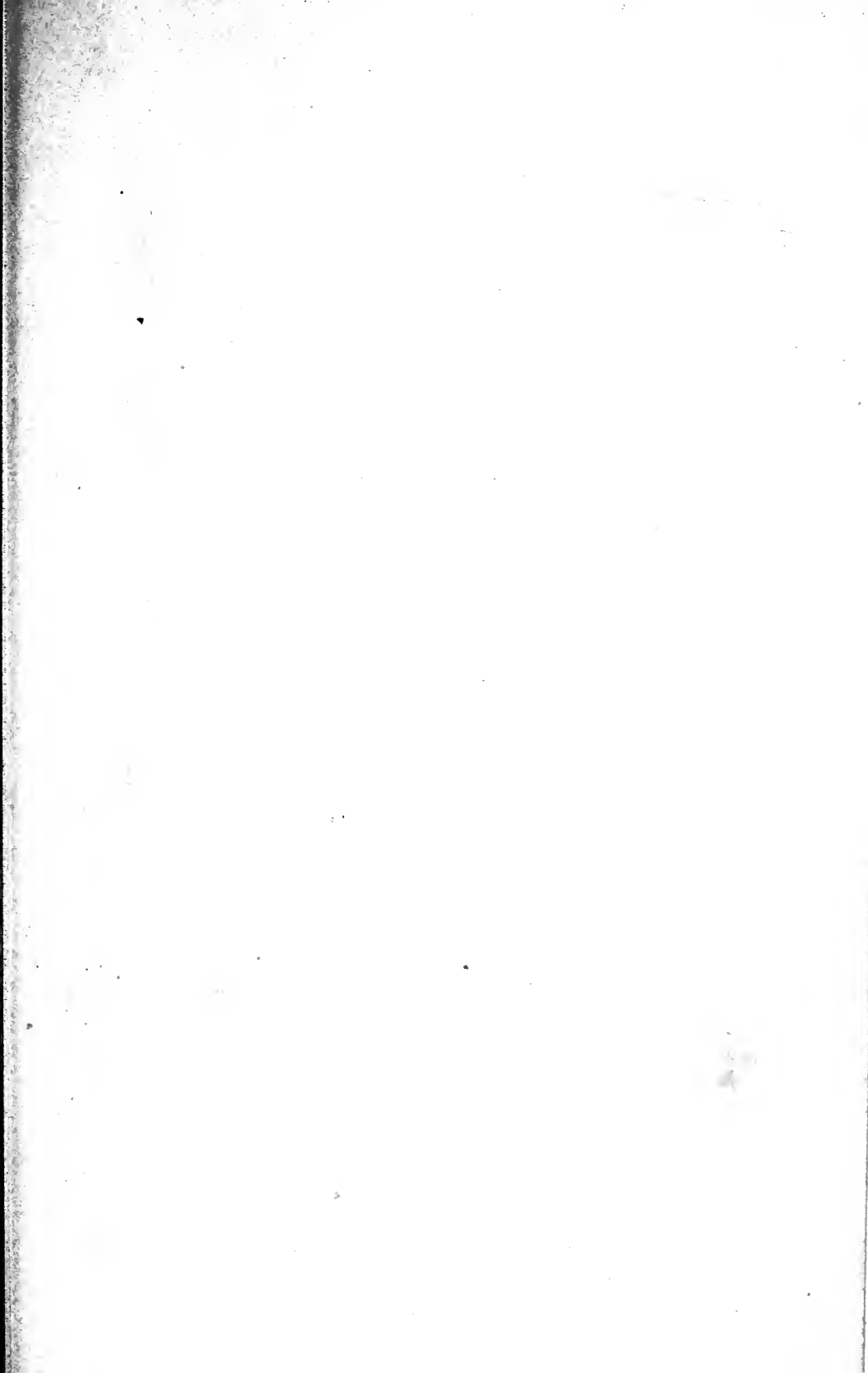
2.—Neutral Fe_2Cl_6 added to solutions of neutral acetates gives a dark red color, destroyed by addition of either HCl, or HgCl_2 ,

3.—Warmed with a few drops of H_2SO_4 and the same of alcohol, $\text{C}_2\text{H}_5\text{OH}$, the characteristic odor of ethyl acetate, $\text{C}_2\text{H}_5\text{-(C}_2\text{H}_3\text{O}_2\text{)}$ is developed.

4.—With acetates the odor of acetic acid is developed by warming with sulphuric acid.

CARBONIC ACID, H_2CO_3 , AND CARBONATES.

1.—Acids, such as HCl, produce an effervescence of CO_2 gas.





2.— $\text{Ca}(\text{OH})_2$ and $\text{Ba}(\text{OH})_2$ precipitate white CaCO_3 , and BaCO_3 , soluble in acids with effervescence.

8.—The CO_2 given off in effervescence is colorless and practically odorless—it turns blue litmus paper red, but the blue color is restored on drying and warming. Passed into lime water the gas produces a white precipitate which redissolves with excess of the gas.

CITRIC ACID, $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$, AND CITRATES.

1.— CaCl_2 precipitates from boiling solutions of citrates, white calcium citrate, $\text{Ca}_3(\text{C}_6\text{H}_5\text{O}_7)_2$, soluble in $\text{HC}_2\text{H}_3\text{O}_2$, insoluble in NaOH , soluble in cold NH_4Cl but reprecipitated by boiling. In testing the free acid first render *faintly* alkaline with ammonium hydroxide, then add the CaCl_2 and boil.

2.— AgNO_3 produces with normal alkali citrates a white flocculent precipitate of silver citrate, $\text{Ag}_3\text{C}_6\text{H}_5\text{O}_7$. On long boiling, a partial separation of silver occurs. The precipitate dissolved in NH_4OH and boiled forms no mirror (unlike the tartrate).

3.—Heated on platinum foil, citric acid fuses, carbonizes, and gives off pungent fumes.

OXALIC ACID, $\text{H}_2\text{C}_2\text{O}_4$, AND OXALATES.

1.— CaCl_2 precipitates white calcium oxalate, CaC_2O_4 , soluble in HCl , insoluble in $\text{HC}_2\text{H}_3\text{O}_2$.

2.— AgNO_3 precipitates white silver oxalate, $\text{Ag}_2\text{C}_2\text{O}_4$, soluble in hot concentrated HNO_3 , and in NH_4OH .

3.—Oxalic acid added to a solution of $\text{K}_2\text{Mn}_2\text{O}_8$ acidulated with dilute H_2SO_4 , and warmed gently, completely removes the color.

4.—Oxalates, unlike citrates and tartrates, are not charred when heated with H_2SO_4 .

5.—Heated on platinum foil, oxalates turn gray but do not carbonize. A carbonate is produced, soluble in acids with effervescence.

SALICYLIC ACID, $\text{HC}_7\text{H}_5\text{O}_3$, AND SALICYLATES.

1.— Fe_2Cl_6 in neutral solutions gives a deep violet color. (Compare with test for Phenol.)

2.—Bromine water produces a yellowish-white precipitate. (See, also, Phenol.)

3.—Add methyl alcohol and one-fourth volume of H_2SO_4 ; on

warming, the odor of methyl salicylate ("Oil of Wintergreen") is developed.

4.—Sodium salicylate, added to a solution of copper sulphate, changes the blue color of the latter to a bright green.

TARTARIC ACID, $H_2C_4H_4O_6$, AND TARTRATES.

1.— $CaCl_2$ precipitates from solutions of tartrates, white calcium tartrate, $CaC_4H_4O_6 \cdot 4H_2O$, soluble in $HC_2H_3O_2$. Soluble also in $NaOH$, from which solution it is reprecipitated on boiling. In testing the free acid first render *faintly* alkaline with ammonium hydroxide.

2.—From solutions of normal tartrates, $AgNO_3$ precipitates white silver tartrate, $Ag_2C_4H_4O_6$, which blackens on boiling. If, instead of boiling the mixture, the precipitate be filtered off and dissolved in a few drops of dilute NH_4OH , on boiling, a mirror of silver forms on the tube. (The tube must be absolutely clean.)

3.—Heated on platinum foil, tartaric acid, or tartrates, fuse, carbonize, and give off the characteristic odor of burnt sugar.

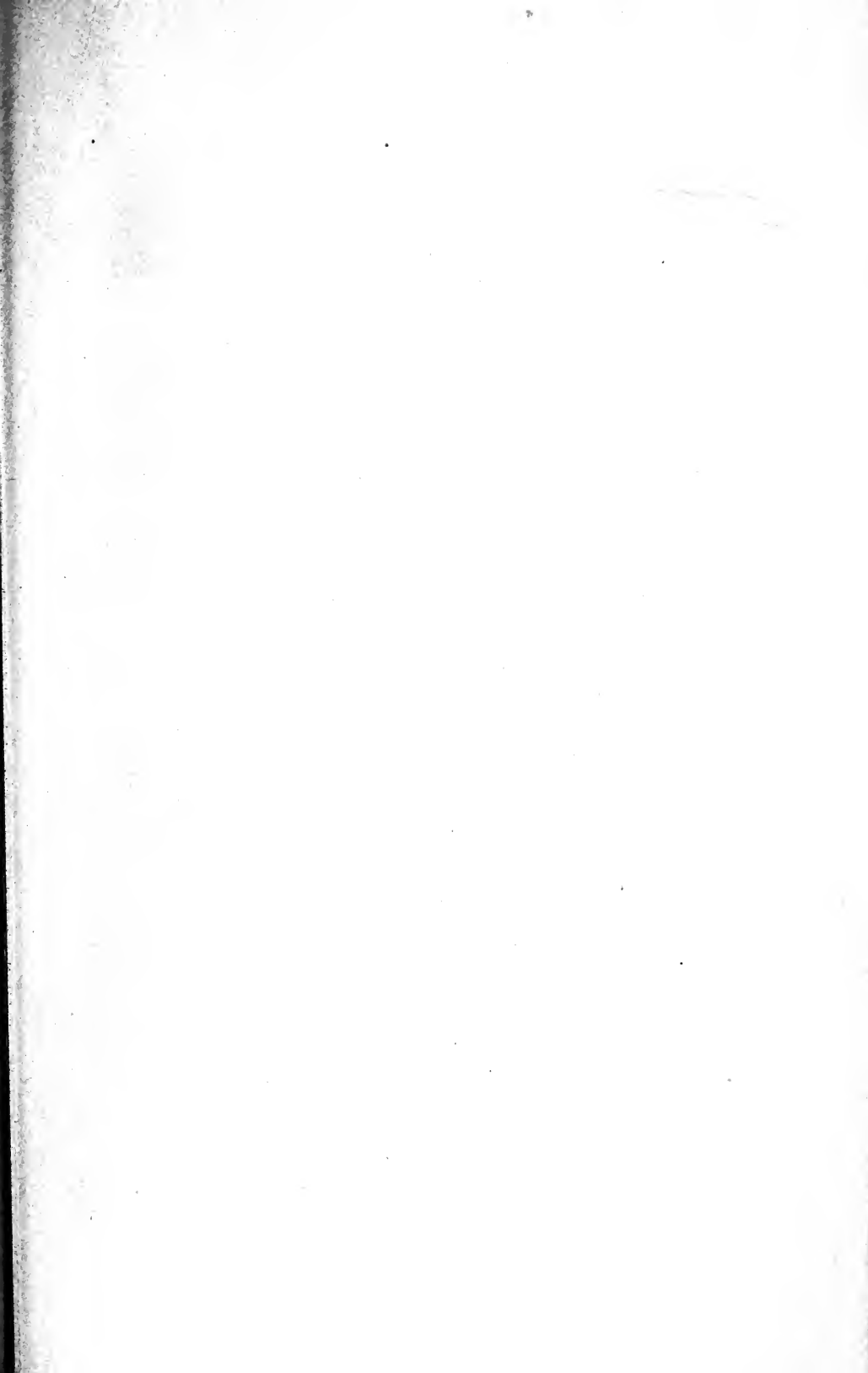
GENERAL PLAN OF ANALYSIS.

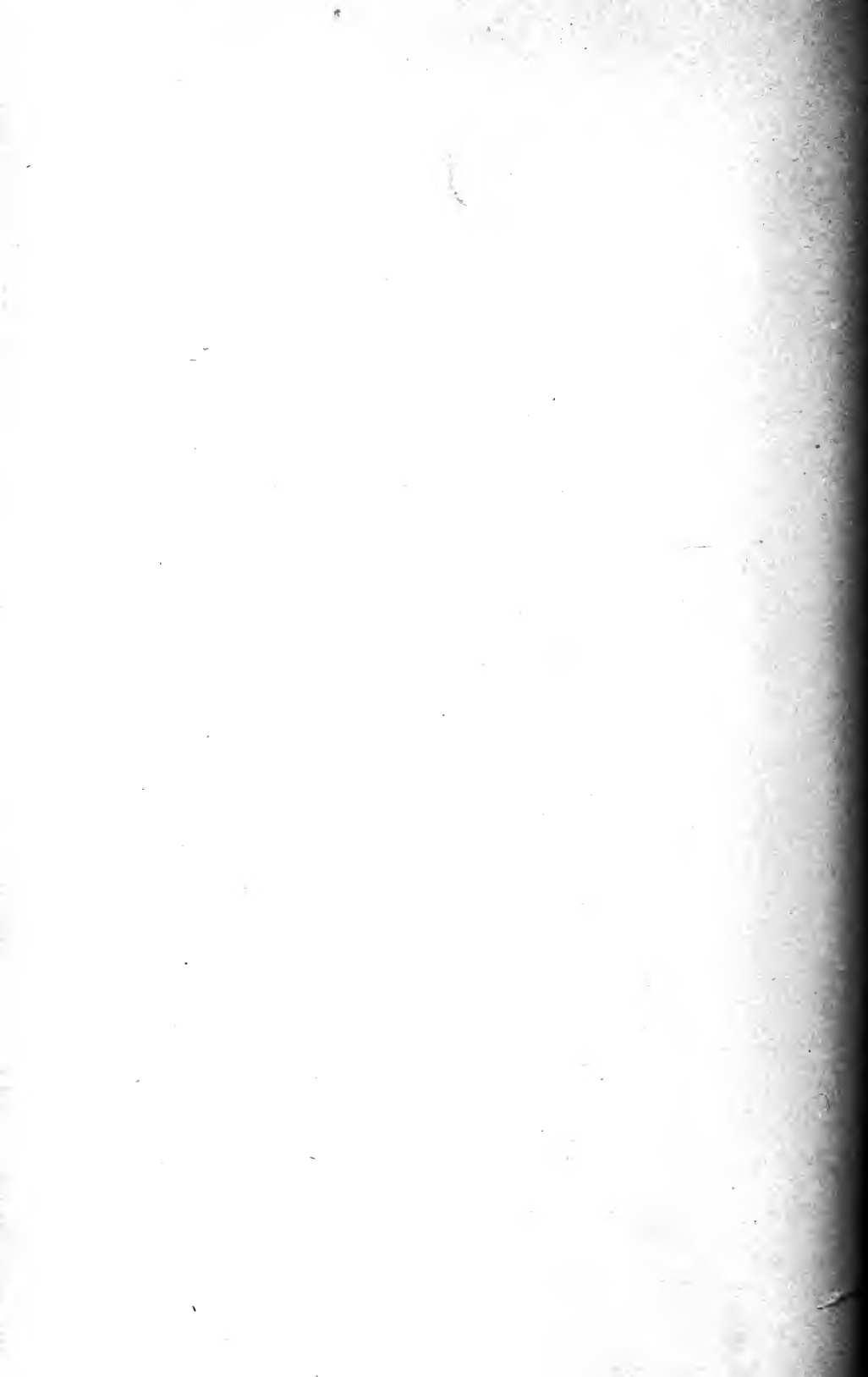
PRELIMINARY EXAMINATION.

Should the substance be in solution, evaporate to dryness and apply the following preliminary tests to the residue :

1.—*Heat a portion of the powdered substance on platinum foil*.—It darkens and chars, giving the odor of burnt sugar. Tartrates, citrates, sugar, etc.: It darkens slightly, leaving a residue of carbonate = oxalates. Proteid matter, alkaloids, etc., produce an odor resembling that of burning hair.

2.—*To a little of the powdered substance in a test-tube add a few drops of H_2SO_4* . Note results before and after warming :—*Colored gas*—Violet fumes = iodides; brown fumes = bromides; yellow-green fumes of Cl = hypochlorites; yellow Cl_2O_4 = chlorates; reddish-brown fumes = nitrites; nearly colorless but faintly reddish-brown fumes = nitrates. *Colorless gas*—Effervescence in the cold, no odor = carbonates; on heating, odor of H_2S = sulphides; odor of SO_2 = sulphites; odor of SO_2 with separation of S = thiosulphates (hyposulphites); odor of HCN = cyanides; odor of $HC_2H_3O_2$ = acetates; acid fumes of HCl = chlorides. Colorless gases are also evolved from hydrofluoric acid, from chromic, citric, oxalic, malic,





and tartaric acids, from formates and ferrocyanides, and characteristic odors are obtained from benzoates, succinates and valerianates. *No gas*—Sulphates, phosphates, silicates, borates, arsenites, arsenates, tungstates, molybdates, iodates, many oxides, etc.

3.—*Heat some of the powder gently in a Bunsen flame*, moisten with HCl and heat again. The flame is colored *yellow* by Na; *violet* by K; *crimson* by Sr; *carmine-red* by Li; *reddish-yellow* by Ca; *green* by Ba, B_2O_3 , and Mo; *emerald-green* by Cu; *bluish-green* by some phosphates; *bluish* by As, Sb, Pb, $CuCl_2$ and $CuBr_2$.

4.—*Heat a small portion of the powdered substance in a dry ignition tube*. It *blackens*:—Organic compounds and certain salts of copper and cobalt. It *changes color*:—Yellow when hot, white when cold = ZnO and many zinc salts; yellow both hot and cold = lead oxide; red-brown when hot, pale yellow when cold = Bi_2O_3 and certain bismuth salts; red to black when hot, reddish-brown when cold = Fe_2O_3 and salts of iron; brown both hot and cold = cadmium salts; brown when hot, yellow when cold = SnO_2 . It *fuses*:—Many alkaline and other salts, also tartaric and citric acids before charring. It *sublimes*:—The sublimate is—gray and easily rubbed into globules = Hg; white crystalline, the substance first melting = $HgCl_2$; sublimate yellow when hot, white when cold = Hg_2Cl_2 ; black, but red on rubbing = HgS ; steel-gray, odor of garlic = As; white octahedral crystals = As_2O_3 ; nearly black when hot, reddish-yellow when cold = As_2S_3 ; substance fuses yellow, white amorphous sublimate = Sb_2S_3 ; reddish-yellow stain = Fe_2Cl_6 ; reddish-brown drops, yellow when cold = S; heavy white vapor and crystalline sublimate = H_2CrO_4 ; violet vapor, bluish-black sublimate = I. A *gas or vapor* is given off:—The gas is O = nitrates, chlorates, iodates, peroxides; H_2S = hydrated sulphides, some sulphites; SO_2 = sulphites, hyposulphites, and a few sulphates; NH_3 = ammonium compounds; Oxides of N = nitrates, nitrites; H_2O = hydrates, and crystalline salts. Fumes are also given off from chromic acid and iodine, from cyanides, from bromine, and from acetates.

5.—*Heated on charcoal*:—The substance *deflagrates* = nitrates, chlorates, iodates, permanganates, etc. An *incrustation* is formed on the charcoal; Yellow when hot, white when cold = Sn, Zn; yellow both hot and cold = Pb, Bi; reddish-brown = Cd; white = As, Sb.

PREPARATION OF THE SOLUTION FOR ANALYSIS.

6.—If the substance be a metal, dissolve in HNO_3 (Au and Pt are insoluble in HNO_3 , soluble in nitro-hydrochloric acid. Sb and Sn may separate as white oxides, filter, wash, and dissolve in HCl.) Evaporate the solution to dryness and dissolve the residue in water containing a little HNO_3 .

If the substance be a solid, but not a metal, reduce it to a powder. To a portion add water and boil: (a) If all, or part, dissolves, examine the solution obtained, for bases. (b) To the portion, if any, insoluble in water, add HCl and boil. (c) Dissolve any remaining residue in HNO_3 , or in nitro-hydrochloric acid. When strong acids are required for the solution, it is best to evaporate the solution to dryness and to redissolve in acidified water before proceeding with the analysis. (d) A residue insoluble in acids may be—silica, silicates: sulphate of barium, strontium, or lead; halogen salts of silver; oxides of iron, manganese, aluminum, chromium, and tin, after high heating; carbon, or sulphur. Carbon may be removed by ignition, sulphur, by solution in CS_2 . The residue may be fused with NaCO_3 , or with a mixture of Na_2CO_3 and NaNO_3 , and the fused mass dissolved in acidified water. Certain of these insoluble substances may be suggested by the results of the preliminary examination, in which case special tests may be used for their identification.

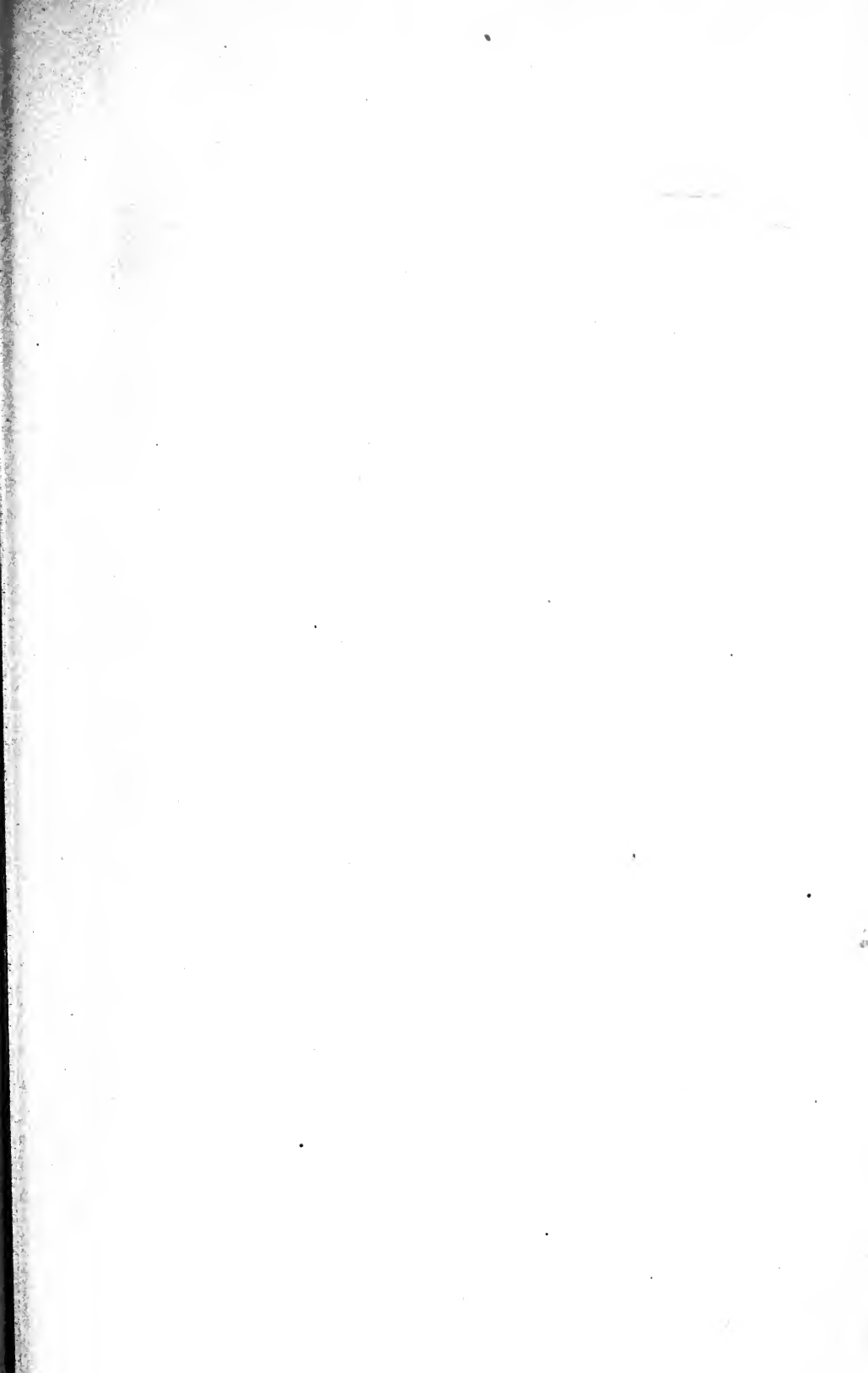
EXAMINATION FOR METALS AND ACIDS.

7.—*For Metals*: Examine for metals according to the Analytical Scheme, page 25. If organic substances be present, ignite the residue, after evaporation of the solution, and dissolve in water acidulated with HCl. Group I. metals will remain undissolved in the hydrochloric acid, and may be tested for in the residue.

8.—*For Acids*: Note that if the substance be soluble in water, acids forming insoluble salts with the metals found can not be present. Refer to the table of solubilities in the Appendix and use the information so obtained in the selection of the tests to follow. The preliminary examination, moreover, may have indicated the possible presence of certain acids, and these may now be tested for directly.

If compounds of the alkalis only are present, proceed at once with the tests given below (A to G).

If metals other than alkalis are present, add Na_2CO_3 to alka-





line reaction, boil, and filter. Divide the filtrate into two unequal parts. To the larger part add HCl until slightly acid, boil thoroughly to remove all CO_2 , and test according to *A*, *B*, *C*, *E*, *F* and *G*. To the smaller portion add HNO_3 to acid reaction, boil to expel all CO_2 , and test according to *D*.

Arsenic or antimony, if present, may be removed by passing H_2S through the solution (slightly acidified if necessary). Filter, to the filtrate add Na_2CO_3 , and proceed as described above. Copper, if present, is more completely precipitated by addition of a little NaOH along with the Na_2CO_3 .

(*A*) Acidify a portion of the solution with HCl. An effervescence = *Carbonates*. (If Na_2CO_3 has to be added, to remove the bases, test the original solid or solution for the carbonates.) Divide into three parts. (*a*) Add BaCl_2 : a precipitate insoluble in hot nitric acid = *Sulphates*. (*b*) Add Fe_2Cl_6 : a dark-blue precipitate = *Ferrocyanides*; a blood-red color destroyed by addition of HgCl_2 = *Sulphocyanates*; a blood-red color not destroyed by addition of HgCl_2 = *Meconates*. (*c*) Add FeSO_4 : a dark-blue precipitate = *Ferricyanides*.

(*B*) Acidify a portion of the solution with $\text{HC}_2\text{H}_3\text{O}_2$. Divide into two parts. (*aa*) Add CaCl_2 : a white precipitate, soluble in HCl = *Oxalates*. (*bb*) Add $\text{NaC}_2\text{H}_3\text{O}_2$ solution and a little neutral Fe_2Cl_6 : a precipitate = *Phosphates*. Note that presence of free mineral acid will prevent this reaction. Phosphates may be tested for, also, by the molybdate test, see page 34.

(*C*) Add to the solution enough dilute NH_4OH to give a *faint* alkaline reaction, then add CaCl_2 : a precipitate soluble in NaOH, but reprecipitated by boiling = *Tartrates*. If no precipitate form after shaking and standing, boil the mixture; a precipitate now forming = *Citrates*.

If sulphates be present test for oxalates, tartrates, etc., as follows, using the filtrate from the precipitate obtained by adding BaCl_2 in (*A*). Render the filtrate faintly alkaline with NH_4OH and add CaCl_2 . Let stand for several minutes, filter, and reserve the precipitate. Boil the filtrate; a precipitate soluble in NH_4Cl and reprecipitated by boiling = *Citrates*.

Wash the precipitate reserved above and pour upon the paper acetic acid; an insoluble residue = *Oxalates*. The acetic acid solution is now tested for *Tartrates*, and for *Phosphates*, by the tests already given.

(*D*) Acidify a portion of the solution with HNO_3 and add AgNO_3 . If a precipitate form, warm the mixture, filter, and wash. Treat the precipitate on the paper with dilute NH_4OH

(1-20). To the solution obtained add HNO_3 ; a precipitate = chlorides, cyanides (oxalates). Boil with strong HNO_3 . If the precipitate be due to *Chlorides* it will remain undissolved, if due to *Cyanides* (or oxalates) it will dissolve. In presence of chlorides, the cyanides may be recognized by their characteristic odor, developed by decomposition of the precipitate with hot HCl .

A residue left after the treatment of the first precipitate with dilute NH_4OH may be bromides or iodides. *Bromides* are soluble in strong NH_4OH ; *Iodides* are insoluble in strong NH_4OH . To further identify these substances, add to the original solution a little starch paste and a few drops of chlorine water, a blue color = *Iodides*. Continue the addition of the chlorine water until the blue color is destroyed, shake with chloroform; the chloroform is colored brownish-yellow = *Bromides*.

(E) Apply the FeSO_4 test for *Nitrates*, see page 31.

(F) To the solution, carefully neutralized if necessary, add neutral Fe_2Cl_6 : A red color easily destroyed by addition of HCl = *Acetates*. (Test for acetates, also, by test 3, page 34.) A red color not destroyed by addition of HCl = *Pyrogallates* (Sulphocyanates, Meconates). Pyrogallates turn black on addition of NaOH and exposure to the air.

A blue-black color on addition of the neutral Fe_2Cl_6 may be due to *Gallates* or to *Tannates*; the latter precipitate gelatin (best after addition of a little alum), the former do not precipitate gelatin.

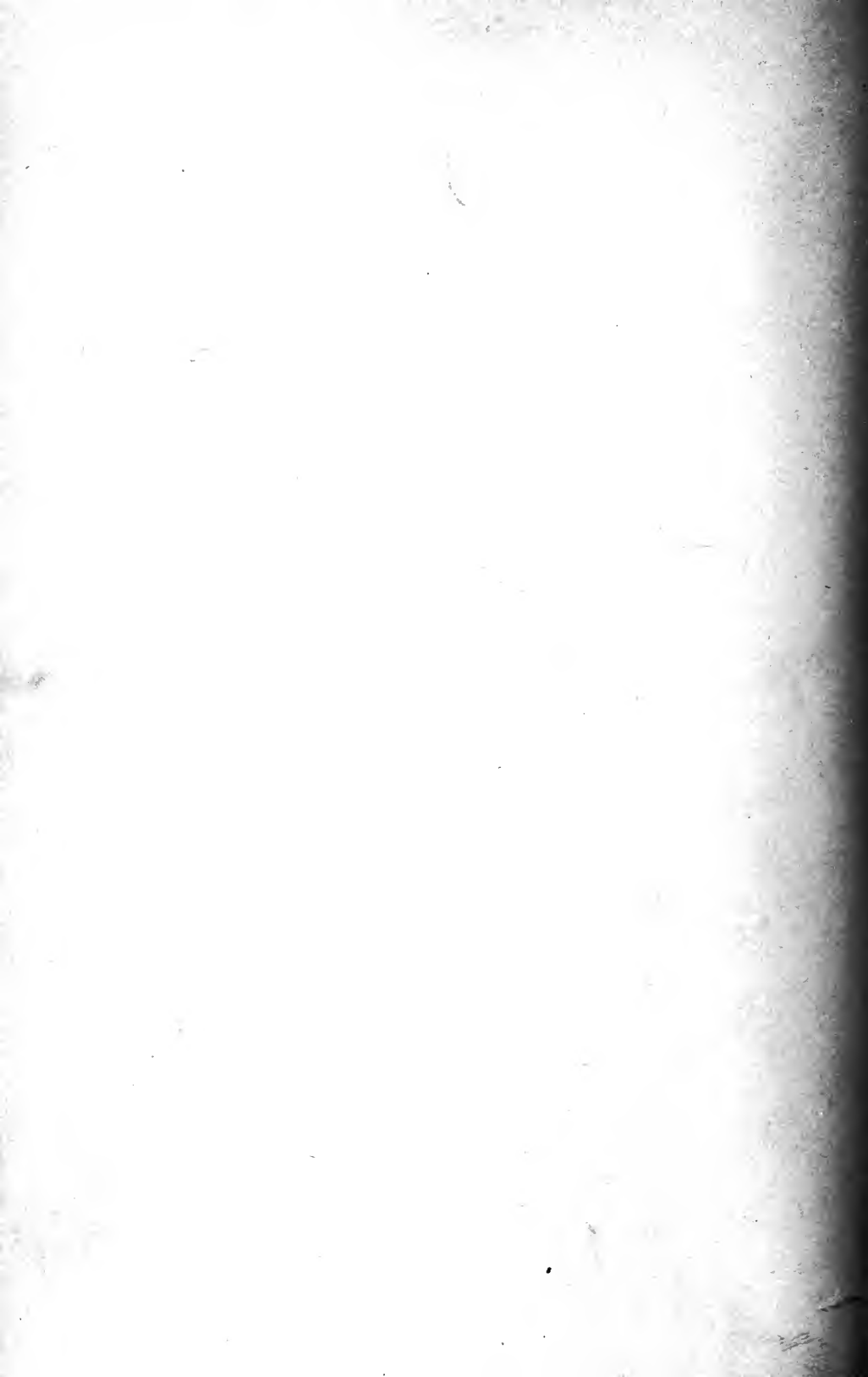
A violet coloration may be due to *Phenol* or to phenol derivatives, *Salicylates*, etc. A pinkish precipitate may be due to *Benzoates* or to *Succinates*. Dissolve the precipitate in dilute NH_4OH , concentrate the solution and add HCl , benzoic acid will separate in silky needles.

(G) Test for *Borates*, see page 32.

9.—Acids other than those mentioned in the last paragraph may be indicated in the preliminary examination, and may be identified by special tests. *Chromates*, *Manganates* and *Permanganates* will be suggested by the color of their solutions, by certain of the preliminary tests and by the determination of their metals in the analysis for bases. They may be identified by the tests given on pages 32 and 33.

Hydroxides and *Oxides* will be suggested by negative results with the foregoing tests. The hydroxides and oxides of the metals of





Groups IV. and V. are nearly all easily soluble in water; other hydroxides and oxides are insoluble in water.

SPECIAL TESTS.

ARSENIC.

1.—Place a small particle of arsenious oxide in a reduction tube, and above it in the tube a splinter of charcoal. Heat first the coal, then the arsenic; a mirror of metallic arsenic will form on the glass above the coal. Remove the coal and heat the mirror; a crystalline sublimate of arsenious oxide will be obtained in the cool portion of the tube.

2.—*Marsh's Test*.—The apparatus consists of a flask provided with a safety tube, for the introduction of the solution, and a delivery tube for the exit of the gases evolved. The latter pass into a wide tube containing calcium chloride, and thence into a long tube of smaller bore, contracted at intervals and drawn to a fine point at the end. Zinc, water, and sulphuric acid are brought together in the flask, and the solution under analysis added. Hydrogen gas, and, in presence of arsenical compounds, arsenetted hydrogen gas are produced. The inflammable gas issuing at the end of the tube, in presence of arsenetted hydrogen burns with a bluish-white flame, and gives off white fumes which may be collected and examined microscopically for crystals of As_2O_3 . If a cold surface, such as a piece of porcelain, be held in the flame, metallic arsenic is deposited in a brilliant steel-gray to brown mirror. By heating the long tube near one of its contractions a fine mirror of arsenic is deposited on the glass just in advance of the flame. If the gas be passed into a solution of silver nitrate, metallic silver is deposited in black flakes. After filtering, the clear solution may be examined for As_2O_3 . Antimony gives somewhat similar tests, but may easily be distinguished. (See under Antimony.) Organic matter must be absent and the reagents used must be absolutely pure.

2.—*Fleitmann's Test*.—This is similar to Marsh's Test, depending upon the production of arsenetted hydrogen by the action of nascent hydrogen on a reducible arsenical compound. Potassium hydroxide or sodium hydroxide is placed with zinc in a test-tube and the solution to be tested added. A paper moistened with silver nitrate is held at the mouth of the tube; the mixture is boiled, and in the presence of arsenic the paper is blackened by

the reduction of the silver nitrate to metallic silver. This test is not given by antimony.

3.—*Reinsch's Test*.—The solution to be tested is acidulated with hydrochloric acid, a strip of pure bright copper foil is introduced and the mixture boiled. In the presence of arsenical compounds, a steel-gray deposit of arsenic forms upon the copper. Antimony, mercury, and even organic matter, may produce a similar appearance, but the arsenic may be identified as follows: The copper slip is removed, washed carefully, and dried between folds of filter paper. A strip is then cut, rolled into a small coil, introduced into clean reduction-tube and heated. The arsenic volatilizes, and collects in the cooler portions of the tube in white octahedral crystals of As_2O_3 . Organic matter is burned away without the formation of a sublimate. (For Antimony and Mercury, see below.)

4.—Heated with charcoal, arsenous and arsenic oxides are volatilized, giving off the characteristic odor of garlic.

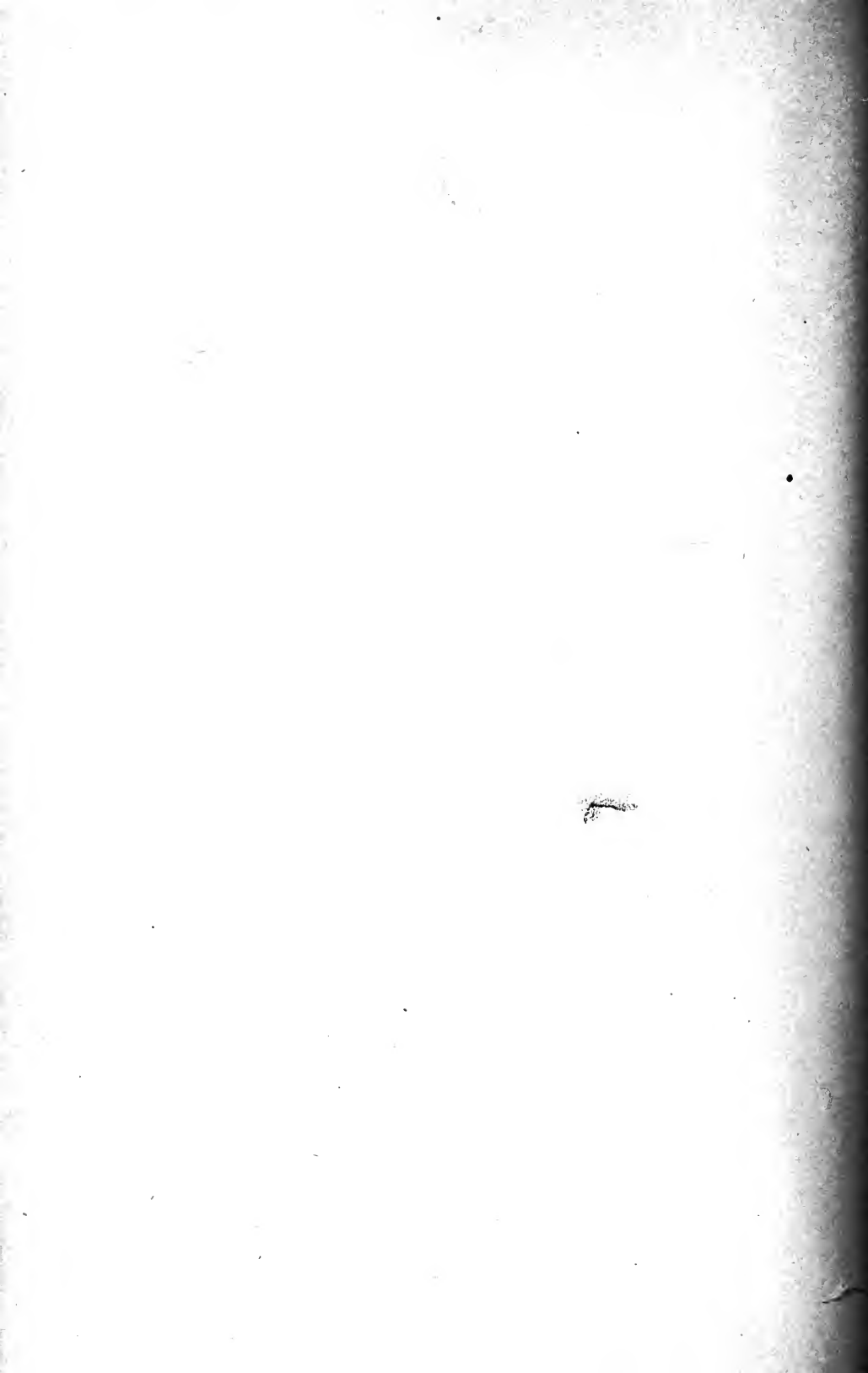
(Other tests for arsenic, see p. 20.)

ANTIMONY.

1.—*Marsh's Test*.—This test is performed as described under arsenic, similar mirrors of metallic nature being formed. Antimony is distinguished from arsenic as follows: The deposit obtained by holding a cold surface in the flame is insoluble in solutions of sodium or calcium hypochlorite (arsenic spots—soluble). If the spot be dissolved in a drop of nitric acid, the solution evaporated to dryness, and the residue moistened with a drop of silver nitrate, no color is developed (arsenic—a brick-red color). The spot dissolved in ammonium sulphide and evaporated to dryness, yields an orange-red residue (arsenic—bright yellow). The antimony mirror obtained by heating the tube is formed immediately above the flame (with arsenic, in advance of the flame), is darker than the arsenical mirror and less volatile. Antimonetted hydrogen does not precipitate metallic silver from solutions of silver nitrate, but does precipitate black silver antimonide.

2.—*Reinsch's Test*.—Performed as indicated under arsenic. The antimony coating is distinguished from arsenic by the fact that when heated in the reduction-tube, the sublimate produced is either amorphous or composed of fine acicular crystals.

(Other tests for antimony, see page 21.)



MERCURY.

1.—The solution to be tested is acidulated with hydrochloric acid, and a strip of pure bright copper is introduced. A deposit of metallic mercury (silvery white by gentle friction) is formed *in the cold*. (Compare with Reinsch's Test for Arsenic.) If the copper be dried and heated as in Reinsch's Test, a sublimate of metallic globules of mercury is formed.

To test for corrosive sublimate in calomel, treat the calomel with hot water, filter, and test the filtrate for mercury. Calomel is insoluble in water, corrosive sublimate is soluble. Calomel is turned black by addition of ammonium hydroxide, corrosive sublimate is not. (Other tests for mercury, see pages 21 and 24.)

ALCOHOL, C_2H_5OH .

1.—To a dilute solution of potassium dichromate add a few drops of strong sulphuric acid, and then a little alcohol, or the solution to be tested. Warm the mixture: it turns green, and the characteristic odor of aldehyde, CH_3COH , is produced.

2.—To the liquid to be tested add a few drops of dilute sodium hydroxide, warm to about $50^\circ C$., then add a solution of iodine in potassium iodide until the liquid is faintly colored. A precipitate of iodoform will be produced. Note the characteristic odor.



An excess of alcohol holds the iodoform in solution.

3.—Add a little sulphuric acid and some strong solution of sodium acetate. The characteristic odor of acetic ether, (ethyl acetate) $C_2H_5(C_2H_3O_2)$, is developed on warming.

4.—To test for "fusel oil" in alcohol, dilute the latter to a strength of about 12 per cent., shake with chloroform, separate and evaporate the chloroform extract. On warming the residue with potassium acetate and a few drops of sulphuric acid, the characteristic odor of amyl acetate will be developed.

Tests for Purity.—It should not affect the color of litmus paper. Fifty c.c. on evaporation should leave no color and no weighable residue, and should give no foreign odor. Mixed with one-half its volume of potassium hydroxide the liquid should not at once become dark colored. Tested with one-twentieth its volume of silver nitrate, the mixture should not become more than faintly opalescent, and, on exposure to diffused daylight for six hours, should not acquire more than a faint brownish tint.

CHLORAL HYDRATE (CHLORAL), $\text{CCl}_3\text{COH} \cdot \text{H}_2\text{O}$.

1.—Add a solution of sodium hydroxide and warm; the chloral is decomposed with the formation of chloroform and sodium formate. Note the odor.

2.—Add the chloral to dilute ammonio-silver nitrate and warm gently; a silver mirror is formed on the tube. This reaction is characteristic of all aldehydes.

3.—Add acetic acid and then ammonium sulphide to a dilute aqueous solution of chloral. A brownish-red color, or precipitate, and a penetrating odor will develop.

4.—Chloral may be extracted from an aqueous solution by agitation with ether. Triturated with camphor, the whole liquefies. Note, also, that chloral will respond to the first test given below for chloroform.

CHLOROFORM, CHCl_3 .

1.—To some alcoholic potassium hydroxide in a test tube add a few drops of aniline, and one or two drops of chloroform, or of the solution to be tested. Warm gently; the disagreeable odor of phenyl-isocyanide, $\text{C}_6\text{H}_5\text{NC}$, is produced.

2.—A strip of paper moistened with chloroform, when ignited, burns with a greenish flame, and gives off fumes of hydrochloric acid.

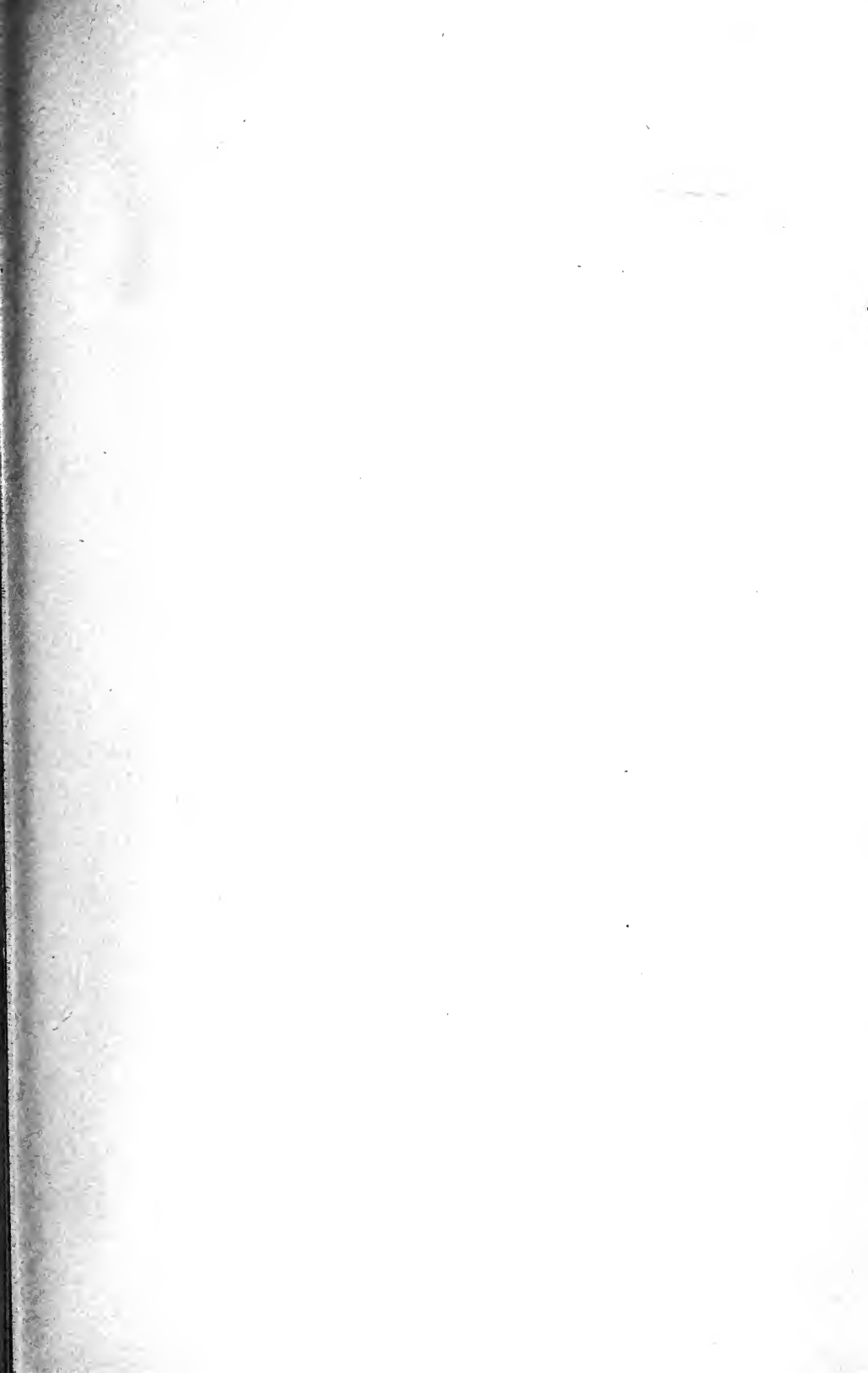
3.—Heat some of the liquid with Fehling's solution. Red cuprous oxide is precipitated as in the test for dextrose (q. v.).

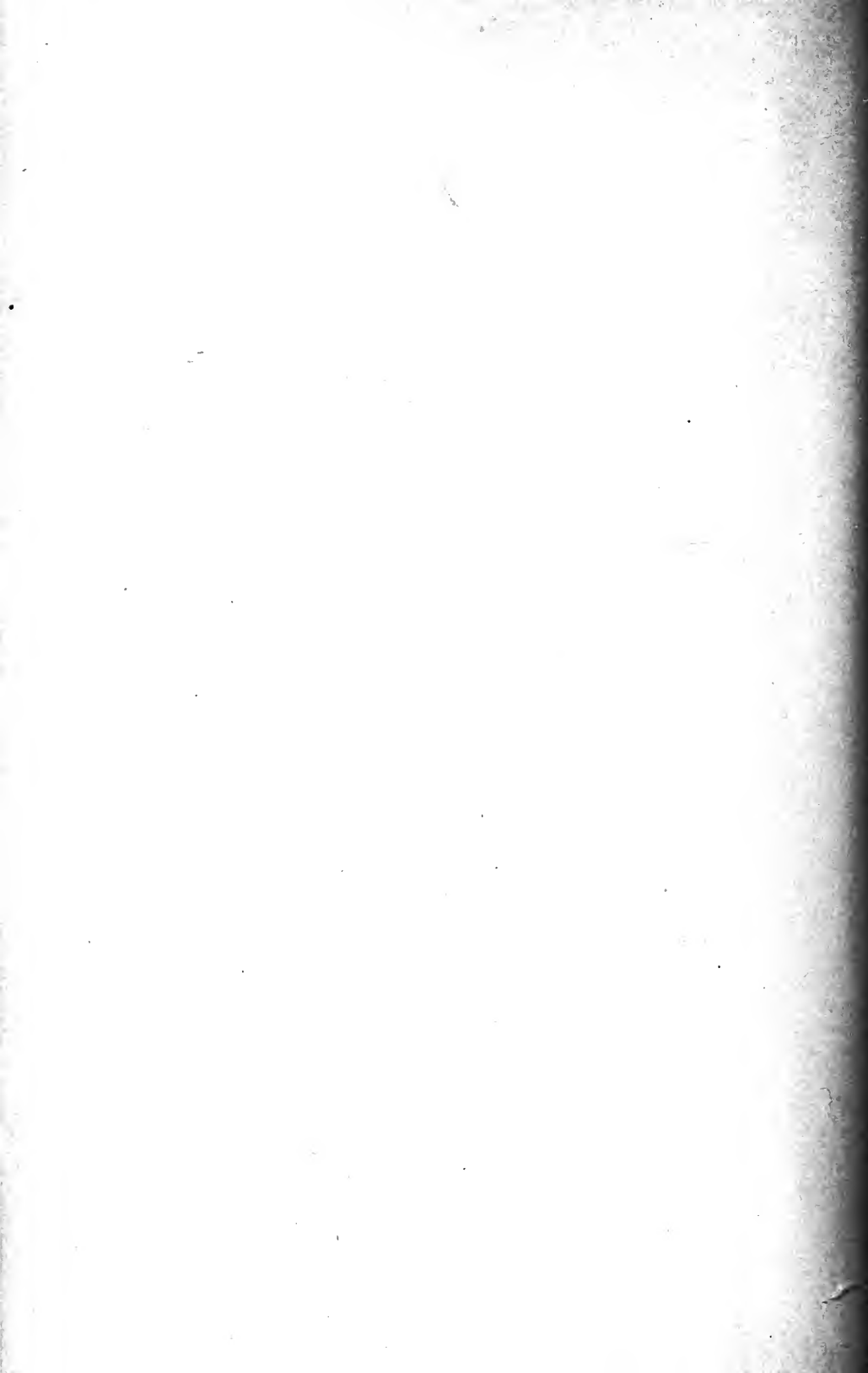
4.—Evaporate an alcoholic solution of phenol and potassium hydroxide, and to the hot residue add a few drops of chloroform, or of the liquid to be tested. A reddish-purple color is developed.

Tests for purity.—Should yield no foreign odor on evaporation. Shaken with water the latter on evaporation should be neutral to litmus and should not be affected by addition of silver nitrate or of potassium iodide. With barium hydroxide in a corked tube, on standing for several hours in a dark place, there should be no film at the contact of the two liquids. Shaken with one-tenth part of strong sulphuric acid, and allowed to stand, the chloroform should remain colorless and the acid should not be more than faintly colored.

ETHYL ETHER (C_2H_5)₂O.

Ether is best recognized by its odor, volatility, and inflammability. It burns with a luminous flame.





Tests for purity.—Ether should boil at about the temperature of the body. Should not affect the color of litmus paper; should leave no residue and should give no foreign odor on evaporation. Twenty c.c. of ether mixed with 20 c.c. of water previously saturated with ether, should show not less than 19.5 c.c. of ether after separation of the two liquids. Shaken with one-tenth part of potassium hydroxide solution, there should be no color in either liquid after one hour.

FORMALDEHYDE, HCOH .

Produced by the oxidation of methyl alcohol, is a gas, soluble in water and in alcohol. (Formalin is a 40 per cent. aqueous solution.)

Phenylhydrazin test. To 1 c.c. of the liquid add 2 drops of a solution consisting of 1 gramme of phenylhydrazin hydrochloride with 1.5 grammes of sodium acetate in 10 c.c. of water, then add 2 drops of sulphuric acid. A green color is developed (in dilute solutions slowly, and best after warming).

For other tests, see under Milk Analysis.

GLYCEROL (GLYCERIN), $\text{C}_3\text{H}_5(\text{OH})_3$.

1.—Add sodium hydroxide to a slightly alkaline reaction, and heat, in a non-luminous flame, a borax bead moistened with this solution. Boric acid is produced and the flame is colored green.

2.—Warm the solution with sulphuric acid. The characteristic odor of acrolein, $\text{C}_3\text{H}_4\text{O}$, is produced.

3.—To detect glycerol in a saccharine liquid, mix the latter with $\text{Ca}(\text{OH})_2$ and sand, and evaporate on a water bath. Extract the nearly dry residue with alcoholic ether and evaporate the extract. Test the residue with the borax bead, as in test 1.

For medicinal use, the aqueous solution of glycerol should be neutral to litmus paper; no brown color should develop when it is treated with sulphuric acid, and no red precipitate should be obtained on heating with Fehling's solution.

HYDROGEN DIOXIDE, H_2O_2 .

A colorless, odorless liquid, with slight acid taste and reaction, the acidity being due to acid used in the manufacture.

To 10 c.c. of water in a test tube add 1 drop of potassium chromate, 10 drops of dilute sulphuric acid, a few c.c. of ether, and then a few drops of the hydrogen dioxide, or of the solution

to be tested. The presence of the dioxide is indicated by the production of a blue color.

PHENOL (CARBOLIC ACID), C_6H_5OH .

1.—Note the characteristic odor, and the greasy stain upon paper.

2.—Heated with excess of strong nitric acid the solution turns yellow, trinitrophenol (picric acid), $C_6H_2(NO_2)_3OH$, being formed.

3.—A few drops of ferric chloride impart a violet-blue color to the solution. Alcohol should be absent.

4.—Add a few drops of the solution to a little hydrochloric acid in a test tube, then add one drop of nitric acid and warm gently. A purple-red color is developed.

5.—Mix the solution with one-quarter volume of ammonia, add a few drops of sodium hypochlorite solution, and warm. A bluish-green color is developed, turning to a red on addition of hydrochloric acid.

6.—The addition of bromine water produces a precipitate of tribrom-phenol, $C_6H_2Br_3OH$, soluble in excess of phenol.

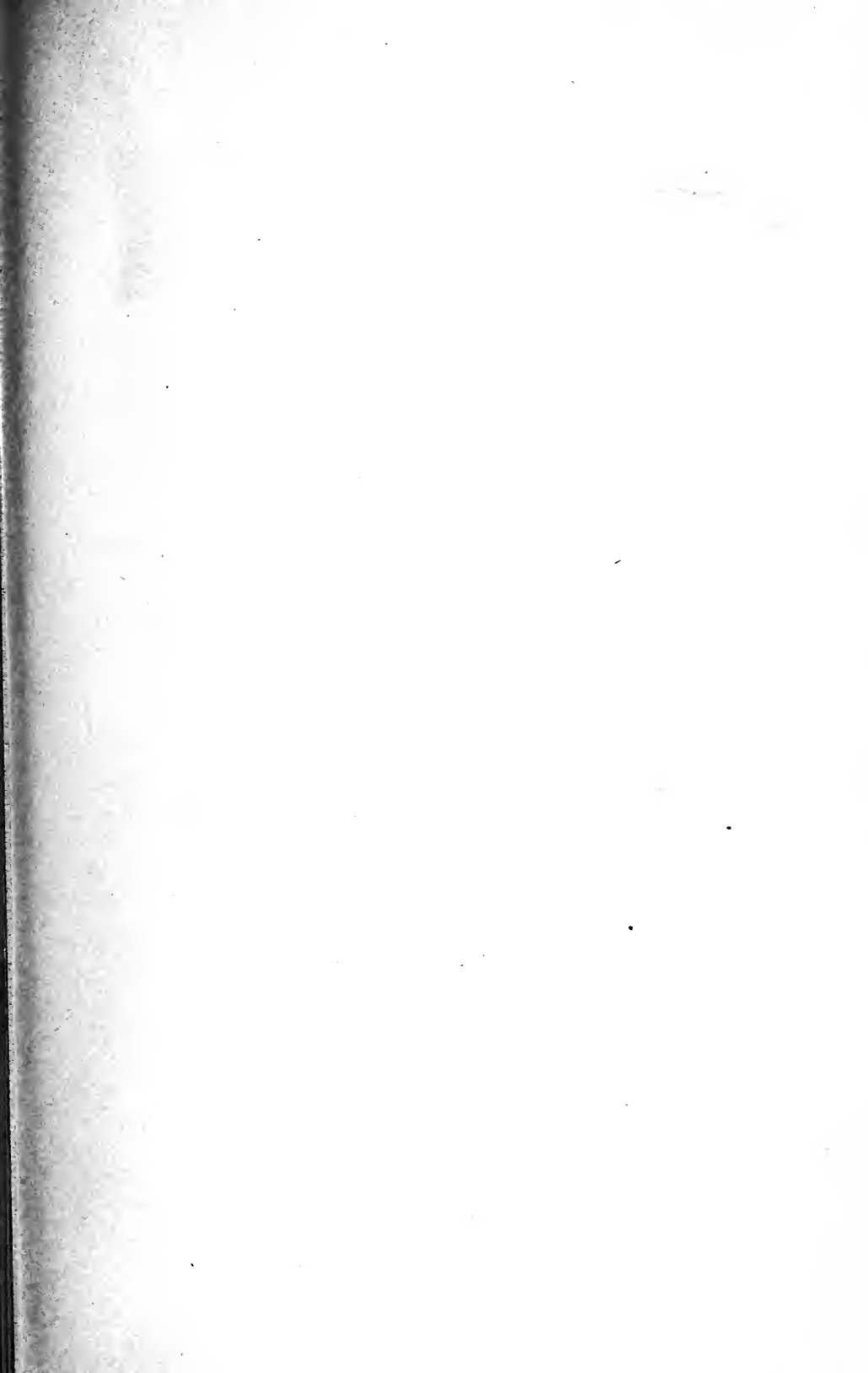
7.—Add a few drops of Millon's reagent (see Appendix) and heat to boiling; an intense dark red color is obtained.

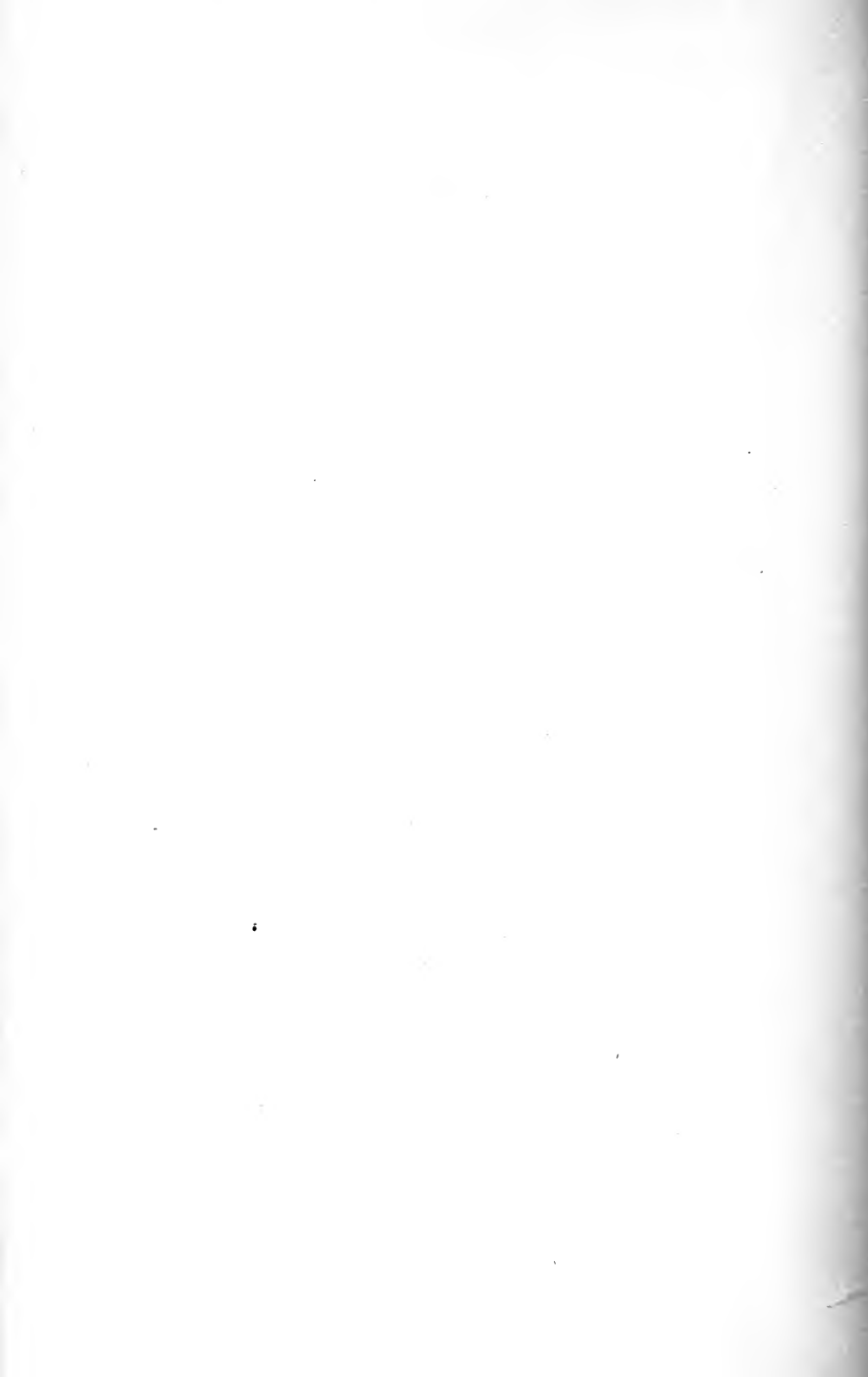
TESTS FOR THE COMMON ALKALOIDS.*

The alkaloids may be described as organic, nitrogenous substances, basic in character, capable of combining directly with acids to form salts. They are commonly divided into two groups: (1) Liquid or Volatile Alkaloids, containing carbon, hydrogen and nitrogen. *Nicotine*, *Sparteine*, and *Coniine*. (2) Fixed or Non-Volatile Alkaloids, containing carbon, hydrogen, nitrogen and oxygen. *Morphine*, *Quinine*, *Atropine*, *Strychnine*, etc.

General Properties.—Most alkaloids are insoluble, or very slightly soluble in water; more soluble in alcohol, chloroform and benzene. The salts of the alkaloids, on the other hand, are generally soluble in water and in alcohol, and less soluble in chloroform and ben-

* Unless otherwise instructed, the tests for alkaloids should be made upon watch glasses, a minute crystal of the alkaloid being dissolved in as little of the solvent as possible, and the reagent added drop by drop. A soluble salt of the alkaloid may be used, or a solution may be made in water slightly acidulated with sulphuric acid.





zene. In appearance, they are generally white, with strong taste, and characteristic physiological action. The hydroxides of the alkalis and alkaline earths precipitate alkaloids from aqueous solutions of their salts. Alkali carbonates precipitate most of the alkaloids. Among other precipitants applicable in general to the whole class, we have tannic acid, picric acid, phospho-molybdic acid, solution of iodine in potassium iodide, mercuric potassium iodide (Mayer's solution), and the chlorides of platinum and gold.

VOLATILE ALKALOIDS.

These are volatile liquids, colorless when pure and first separated, but turning brown on exposure to the air. They are characterized by disagreeable penetrating odors.

Nicotine, $C_{10}H_{14}N_2$. 1.—Acrid odor and taste (*a rapidly fatal poison*), soluble in ether, chloroform, turpentine, water and alcohol.

2.—Picric acid, platinic chloride, and mercuric chloride produce precipitates generally amorphous at first, changing to crystalline. The alkalis, potassium iodide, and potassium chromate, give no precipitates.

3.—If a drop be placed upon a watch-glass and covered with a second watch-glass carrying a drop of hydrochloric acid, white fumes are produced.

4.—An ethereal solution of iodine added to an ethereal solution of the alkaloid separates a brownish oil, which gradually becomes crystalline.

5.—With the pure alkaloid, strong hydrochloric acid develops a violet color; nitric acid, an orange-red color; sulphuric acid shows no change.

Coniine, $C_8H_{17}N$. 1.—Resembles nicotine, less soluble in water, freely soluble in ether and chloroform.

2.—Picric acid and mercuric chloride give precipitates. The alkalis, potassium iodide, potassium chromate, and platinic chloride, give no precipitates.

3.—If a drop be placed upon a watch-glass and covered with a second watch-glass carrying a drop of hydrochloric acid, white fumes are produced and the drop of coniine slowly becomes crystalline.

4.—With strong hydrochloric acid, or with nitric acid and coniine, a pale red mixture is obtained, the color becoming darker on standing. If the mixture be allowed to evaporate spontan-

ously, crystals separate. Evaporated with sulphuric acid a red color is developed, changing to green.

Sparteine, $C_{15}H_{26}N_2$. 1.—In general character similar to coniine.

2.—An ethereal solution of iodine added to a slightly ammoniacal ethereal solution of sparteine, separates minute dark greenish-brown crystals.

NON-VOLATILE OR FIXED ALKALOIDS.

By far the greater number of alkaloids belong to this class. They are mostly white, odorless solids, fusing at a temperature above 100° C. without change, but decomposed when heated above their fusing points.

Aconitine, $C_{33}H_{43}NO_{12}$ (crystalline variety). 1.—A white powder slightly soluble in cold water, more soluble in hot, soluble in alcohol, ether and chloroform. A rapidly fatal poison.

2.—Solutions of aconitine are precipitated by potassium chromate, picric acid, and platinic chloride. Mercuric chloride and potassium iodide give no precipitates.

3.—Dissolved in aqueous phosphoric acid and the solution evaporated, a violet color is produced.

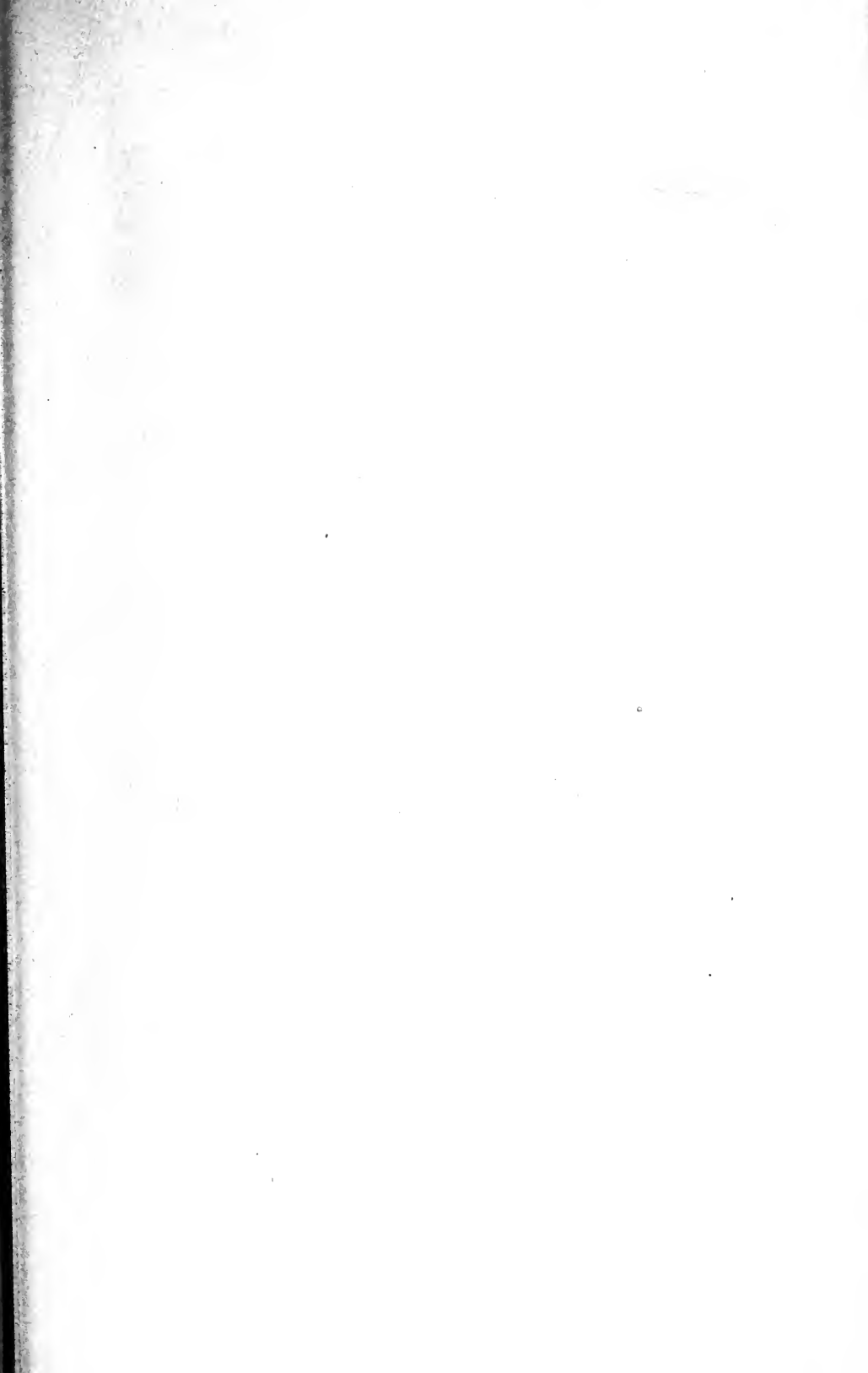
4.—With concentrated sulphuric acid a yellowish solution is obtained; with nitric acid, a red-brown solution. The colors obtained, however, vary, and are probably due to impurities.

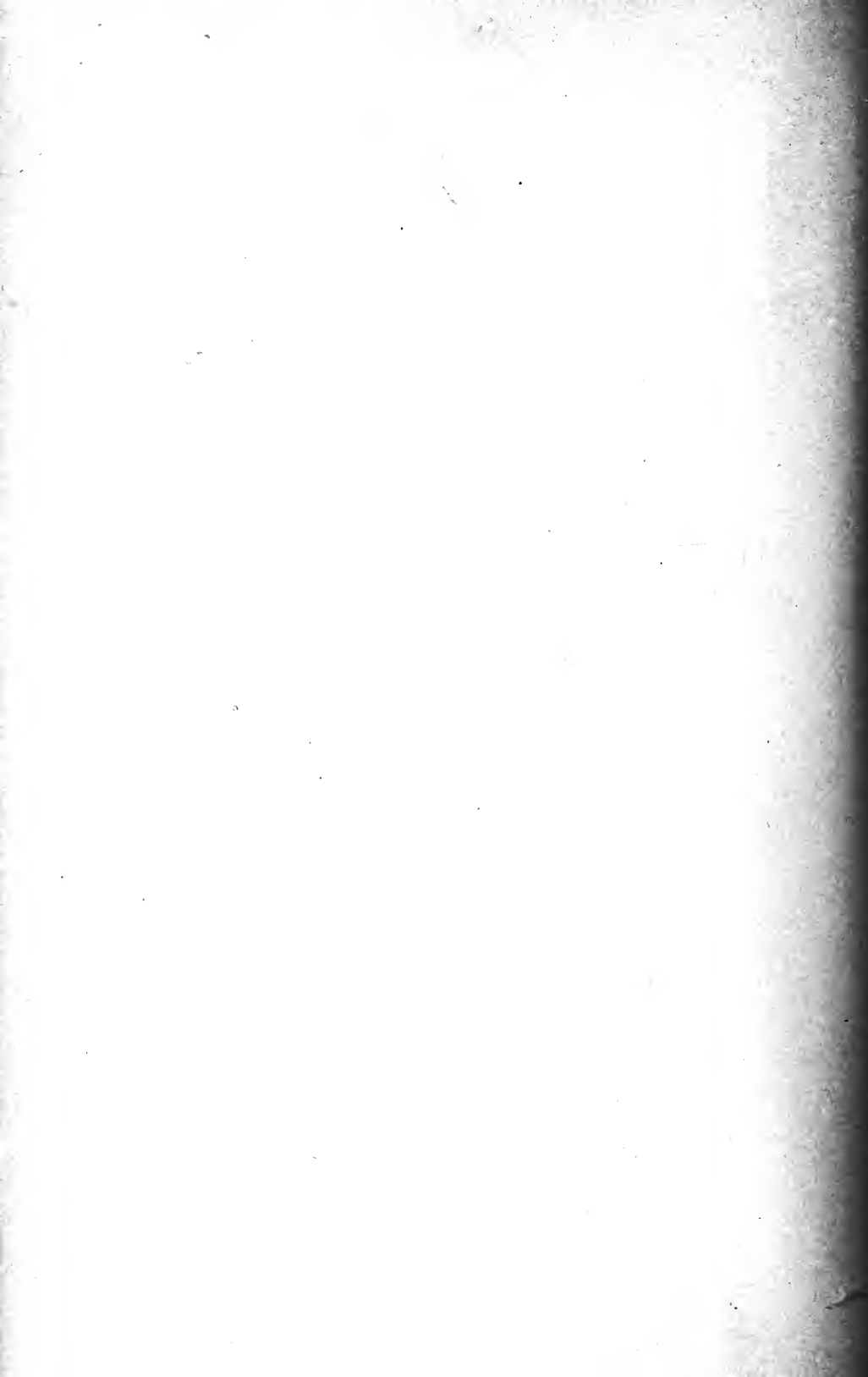
Atropine, $C_{17}H_{23}NO_3$. 1.—White crystalline powder, sparingly soluble in cold water, more soluble in hot water, and easily soluble in alcohol, ether and chloroform. The solutions are alkaline in reaction.

2.—Picric acid, and gold chloride, produce precipitates. Potassium iodide, potassium chromate, and platinic chloride give no precipitates. Mercuric chloride precipitates atropine from alcoholic solutions.

3.—Dissolve a fragment of potassium dichromate in sulphuric acid, add a grain of atropine and a few drops of water, and warm the mixture. A pleasing odor resembling that of orange blossoms is developed.

4.—Moisten the alkaloid with strong nitric acid, dry on the water-bath (= colorless residue with odor of hawthorn) cool and add a few drops of alcoholic potassium hydroxide. A violet color is developed, changing slowly to red.





5.—Warmed with sulphuric acid, an odor of hawthorn is developed. There should be no change of color, either with sulphuric, or with nitric acid.

6.—The physiological test, dilatation of the pupil, is characteristic.

Brucine, $C_{28}H_{26}N_2O_4 \cdot 4H_2O$. 1.—Soluble in alcohol and chloroform, sparingly soluble in water and in ether. The physiological action is similar to that of strychnine, though not so energetic.

2.—Solutions of brucine are precipitated by potassium iodide, potassium chromate, picric acid, platinic chloride, and mercuric chloride.

3.—Chlorine water added slowly to a strong solution of brucine, develops a red color, changed to yellowish-brown by ammonia.

4.—Treated with strong nitric acid brucine is colored red, turning to a yellow on standing. Addition of stannous chloride changes the red to a violet. (With morphine, stannous chloride gives no change.)

5.—Sulphuric acid gives a colorless solution.

Caffeine (Theine), $C_8H_{10}N_4O_2 \cdot H_2O$. 1.—Long silky needles, soluble in water, more soluble in alcohol. The solutions are neutral in reaction.

2.—Mercuric chloride gives a crystalline precipitate. Potassium iodide, potassium chromate, picric acid, and platinic chloride give no precipitates.

3.—Dissolve the alkaloid on a watch glass in a few drops of concentrated hydrochloric acid, add a minute crystal of potassium chlorate, and evaporate, gently, to dryness. Add a drop of dilute ammonia, or invert over a second watch glass containing a few drops of ammonia. The fine purple color so obtained is destroyed by addition of sodium hydroxide.

4.—Caffeine forms colorless solutions in nitric and sulphuric acids.

Cinchonine, $C_{19}H_{22}N_2O$. 1.—Forms in white crystalline needles almost insoluble in water, slightly soluble in alcohol and chloroform, easily soluble in dilute acids.

2.—Solutions of cinchonine are precipitated by potassium iodide, potassium chromate, picric acid, platinic chloride, and mercuric chloride.

3.—Potassium ferrieyanide gives a precipitate easily soluble in excess.

4.—Chlorine water and bromine water give yellowish-white precipitates.

5.—Colorless solutions are obtained with nitric and sulphuric acids—and the solutions show no fluorescence (unlike quinine).

Cocaine, $C_{17}H_{21}NO_4$. 1.—A white crystalline powder, fusing at $98^\circ C.$, sparingly soluble in water, soluble in alcohol, ether and chloroform. The solutions are strongly alkaline. The hydrochlorate, $C_{17}H_{21}NO_4HCl$, is easily soluble in water, the solutions having a slightly bitter taste and producing a tingling sensation, followed by numbness, on the tongue.

2.—The alkaloid is precipitated by picric acid, platinic chloride, and slightly by mercuric chloride. Potassium iodide and potassium chromate give no precipitates.

3.—Add a few drops of strong hydrochloric acid and then five per cent. chromic acid. An orange crystalline precipitate is obtained on standing.

4.—Add, drop by drop, one per cent. potassium permanganate. Small violet colored crystals are formed.

5.—Solutions in nitric and sulphuric acids should be colorless.

Codeine, $C_{18}H_{21}NO_3 \cdot H_2O$. 1.—Sparingly soluble in water; more easily soluble in alcohol, chloroform and ether.

2.—The solutions are precipitated by potassium iodide, potassium chromate, picric acid, and platinic chloride. Mercuric chloride gives no precipitate.

3.—With chlorine water a colorless solution is obtained, turning red on addition of ammonia.

4.—Nitric acid dissolves codeine, giving a yellow solution.

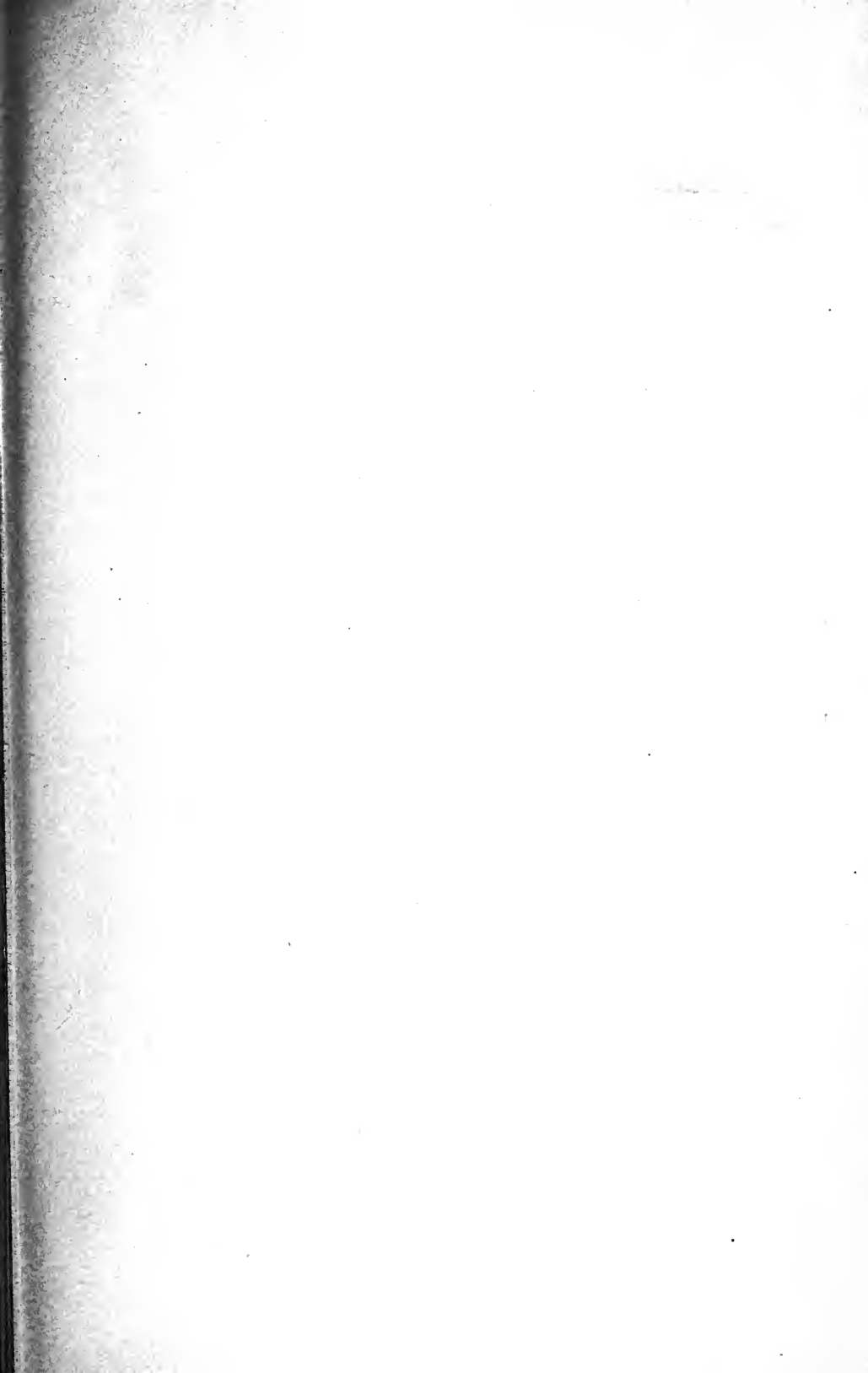
5.—Concentrated sulphuric acid gives a colorless solution which turns blue after several days, or when warmed; best after the addition of a trace of ferric chloride.

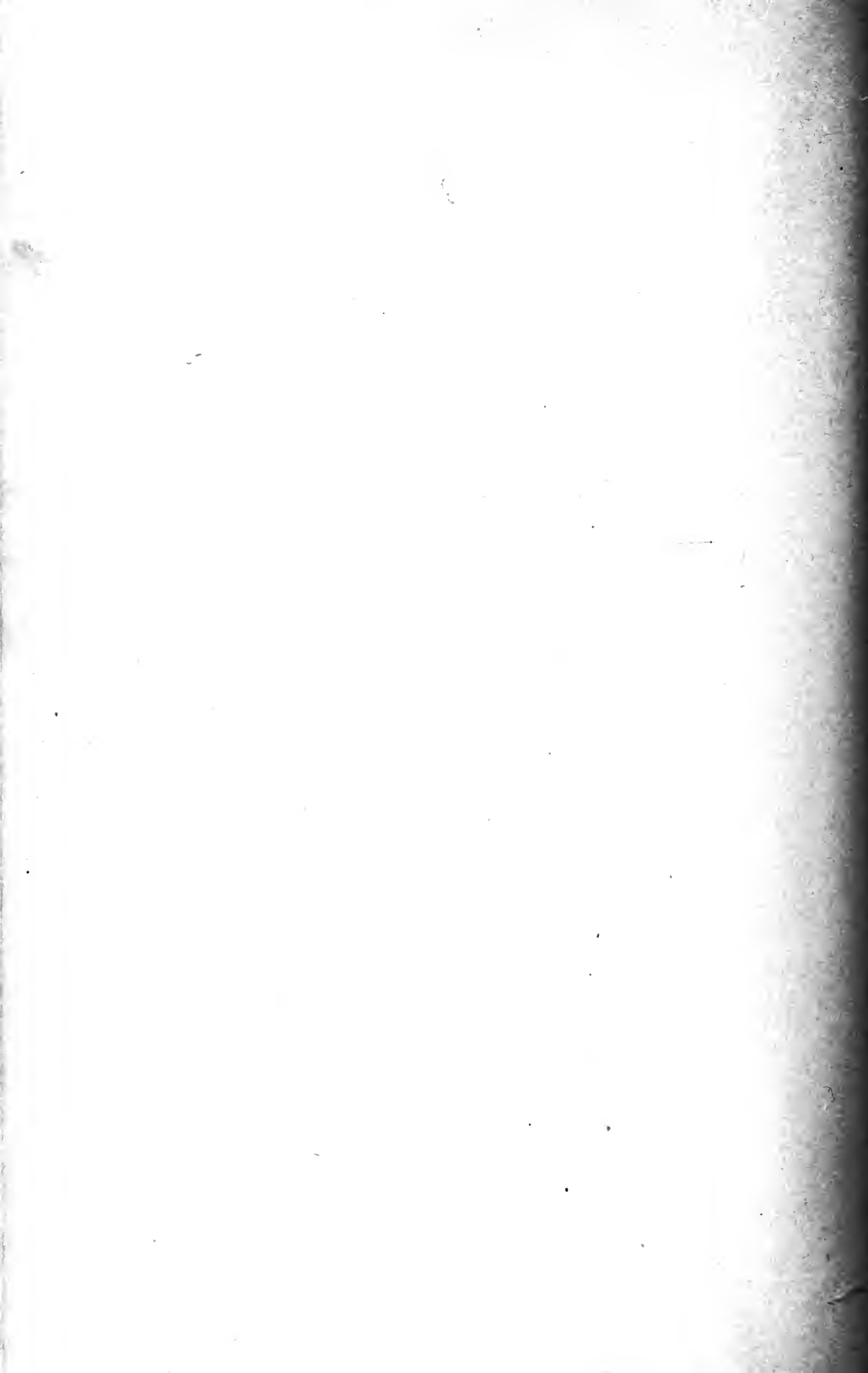
Gelsemine, $C_{12}H_{14}NO_2$. (Gerrard.) 1.—A colorless, odorless substance, with bitter taste and alkaline reaction. Very slightly soluble in water; freely soluble in alcohol, chloroform and ether.

2.—The alkaloid is precipitated by potassium dichromate, picric acid, platinic chloride, and mercuric chloride.

3.—Nitric acid gives a nearly colorless solution, but if this be allowed to evaporate spontaneously a bluish-green stain is left.

4.—Sulphuric acid gives no color with the pure alkaloid. To the sulphuric acid solution add a minute fragment of potassium dichromate. A reddish-purple or cherry-red color appears, and the liquid acquires a greenish-blue or blue color.





Gelsemic Acid. 1.—Colorless, odorless, nearly tasteless, feebly acid substance, nearly insoluble in water, soluble in ether, chloroform, and alcohol. Solubility in water increased by presence of the alkaloid.

2.—With sulphuric acid a faintly yellow solution is obtained. If a drop of ammonia be placed in contact with this solution, a copious crystalline deposit will form.

3.—Nitric acid dissolves gelsemic acid to a yellowish-red solution, which turns to a deep red on addition of ammonia.

Morphine, $C_{17}H_{19}NO_3 \cdot H_2O$. 1.—A white crystalline solid, practically insoluble in ether, chloroform, and water, soluble in boiling alcohol, soluble in amyl alcohol, used generally in form of its more soluble salts.

2.—Morphine is precipitated by iodine in potassium iodide, potassium chromate, picric acid, and platinic chloride. Mercuric chloride gives no precipitate.

3.—Neutral ferric chloride, in neutral solutions, develops a blue color, changing to green with an excess of the reagent.

4.—Nitric acid produces a deep red color, which gradually fades to a yellow. Addition of stannous chloride does not give a violet color. (Unlike brucine.)

5.—Sulphuric acid forms a colorless solution which is turned to a green on addition of a crystal of potassium dichromate, or to a reddish-pink on addition of a trace of nitric acid. The color with the dichromate is best obtained when strong acid has been used, the color with the nitric acid, best when the sulphuric has been dilute.

6.—On boiling with ammonio-cupric sulphate the blue of the reagent is changed to a greenish-blue.

Meconic Acid, $C_7H_4O_7 \cdot 3H_2O$. 1.—Soluble in water, more soluble in alcohol.

2.—To a drop of the solution on a watch-glass add a drop of ferric chloride. A red color appears which is not destroyed by mercuric chloride (differing from ferric sulphocyanate).

3.—Silver nitrate produces a white precipitate which turns red on addition of ferric chloride.

4.—Barium chloride produces a white precipitate.

Quinine, $C_{20}H_{24}N_2O_2 \cdot 3H_2O$. *Quinine sulphate*, $(C_{20}H_{24}N_2O_2)_2H_2SO_4 \cdot 7H_2O$. *Quinine bisulphate*, $C_{20}H_{24}N_2O_2 \cdot H_2SO_4 \cdot 7H_2O$. 1.—A flaky white powder nearly insoluble in water, soluble in dilute acids, in alcohol, chloroform, ether, etc. The sulphate is more soluble in water, and the bisulphate is easily soluble.

2.—Quinine is precipitated by potassium chromate, picric acid, platinic chloride, and mercuric chloride. Potassium iodide gives no precipitate.

3.—Add to an aqueous solution a few drops of bromine water, or of chlorine water, and then an excess of ammonia. A green color is obtained.

4.—To an aqueous solution add chlorine water and a little potassium ferrocyanide. The solution turns pink, then, gradually, red, best after the addition of a *little* ammonia.

5.—Dissolve a few grains of the alkaloid in a little dilute sulphuric acid. A blue fluorescence is obtained. With concentrated nitric acid, a yellowish solution showing a faint bluish fluorescence is obtained.

Strychnine, $C_{21}H_{22}N_2O_2$. 1.—White crystalline powder, with intensely bitter taste (a most dangerous poison). Sparingly soluble in alcohol, and ether, almost insoluble in water, freely soluble in chloroform and in dilute acids. The official salt is the sulphate, $(C_{21}H_{22}N_2O_2)_2H_2SO_4 \cdot 5H_2O$.

2.—Strychnine is precipitated by potassium iodide, potassium chromate, picric acid, platinic chloride, and mercuric chloride.

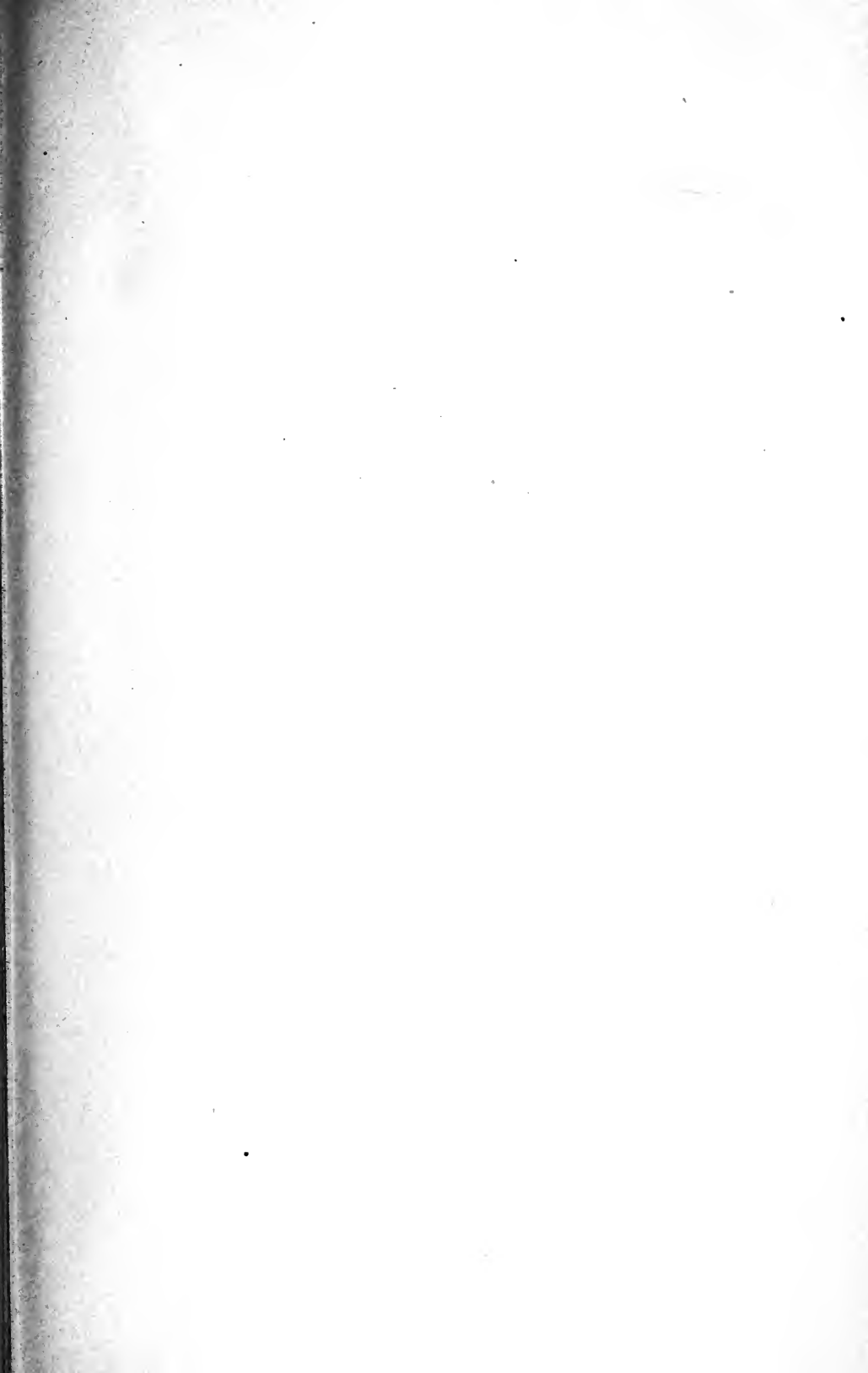
3.—Dissolve a minute crystal of strychnine in one or two drops of strong sulphuric acid, and draw through the solution, which should be colorless, a small fragment of potassium dichromate. A blue color is developed, rapidly changing to violet, cherry-red, and finally to yellow. Black oxide of manganese, potassium ferricyanide, or potassium permanganate may be used in place of the dichromate. The permanganate, however, colors the solution, and thus interferes with the delicacy of the test.

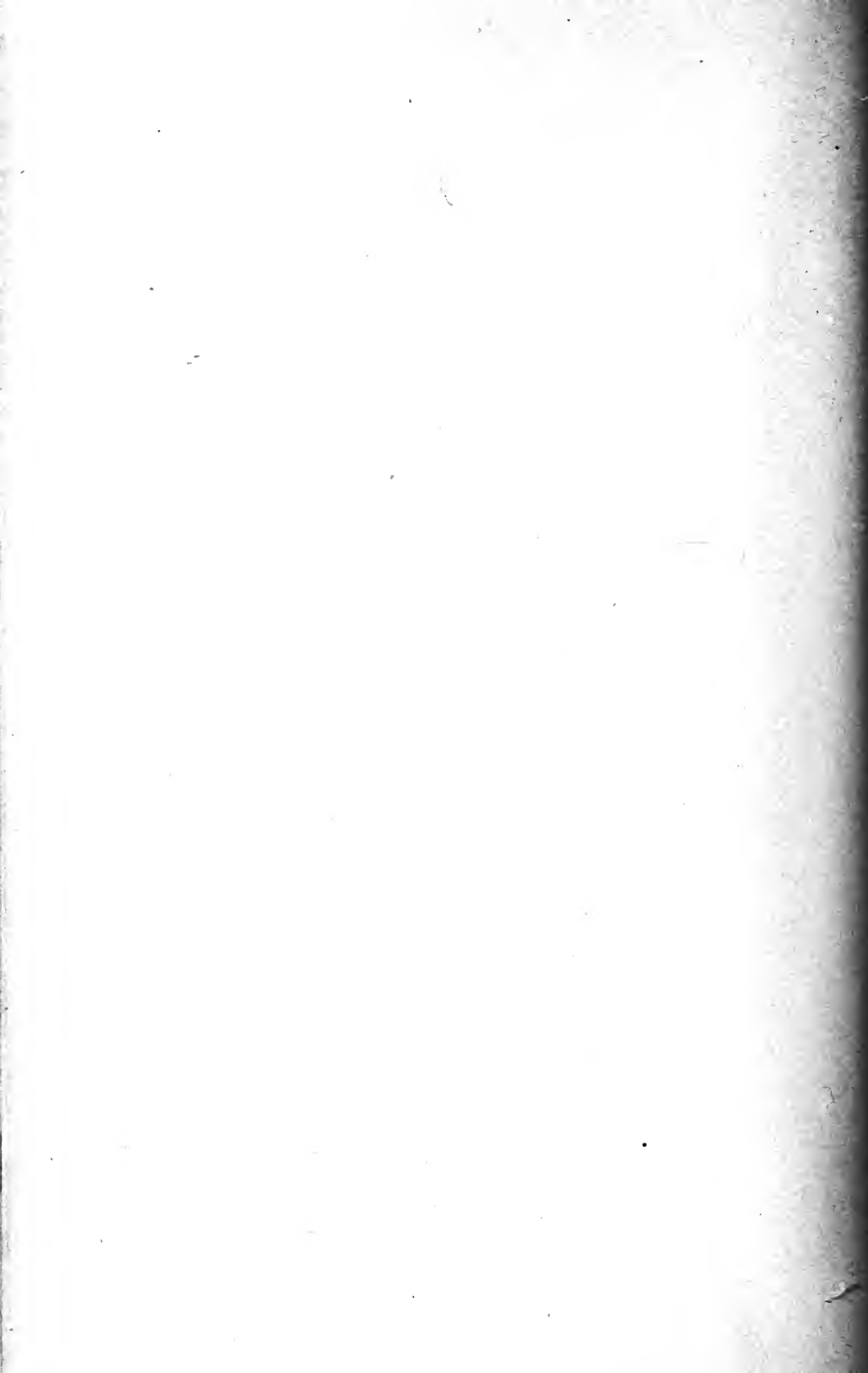
4.—Dissolved in strong nitric acid the solution should be colorless, and on evaporation should yield an odorless yellow residue. (Compare with atropine and brucine.)

5.—Add a drop of nitric acid, warm, and add a small crystal of potassium chlorate. A scarlet coloration is obtained, turning to a brown on addition of ammonium hydroxide.

Veratrine, $C_{32}H_{50}NO_9(?)$. 1.—White amorphous, occasionally crystalline, powder, bitter taste, insoluble in water, soluble in alcohol, chloroform, ether, etc. When heated it melts and gives off acrid fumes.

2.—Amorphous precipitates are obtained with potassium iodide, potassium chromate, picric acid, platinic chloride, and mercuric chloride.





3.—Hydrochloric acid dissolves the alkaloid, forming a colorless solution. On warming, a fragrant odor is developed and the solution gradually turns red.

4.—Sulphuric acid dissolves it, giving a solution yellow at first, turning to an orange and finally to carmine-red. The solution shows a partial green fluorescence.

5.—With nitric acid a yellow solution is obtained.

The quantitative estimation of alkaloids is described in the section on Volumetric Analysis.

GLUCOSIDES, PTOMAINES, AND LEUCOMAINES.

The Glucosides, substances mostly of vegetable origin, derive their class name from the fact that one of their decomposition products is a glucose or similar body. In their analytical and physiological properties, as well as in their origin, they are not unlike the alkaloids, from which, however, they differ in constitution. As examples we may name: Amygdalin, bryonin, digitalin, helleborin, salicin, etc.

The Ptomaines may be defined as basic compounds formed by the action of bacteria on nitrogenous organic matter. Though differing from the alkaloids in origin, they are alkaloidal in nature, and simulate the true alkaloids in their behavior with reagents. They are not to be confused with those other products of bacterial action, the Bacterial Proteids, and the Toxines of disease, nor with the similar Serpent Venoms. As examples of the ptomaines we have: Putrescine, cadaverine, neurine, typhotoxine, mytilotoxine and tyrotoxin.

The Leucomaines are alkaloidal products of normal body metabolism, and are exemplified by adenine, xanthine, hypoxanthine, carnine, spermine, and xantho-creatinine.

SEPARATION OF METALS, ALKALOIDS, ETC., FROM ORGANIC MATTER.

The special tests given for the metals and alkaloids are, as a rule, applicable only in absence of organic matter. When, as is often the case, an organ, a tissue, or an organic fluid is presented for examination, it becomes necessary to either remove or destroy the organic matter before proceeding with the analysis. Many processes have been proposed, but all, though simple in theory, require expert chemical knowledge for their successful application.

The methods given below for metals are particularly adapted to the separation of arsenic, but apply with slight modifications to all of the metallic poisons.

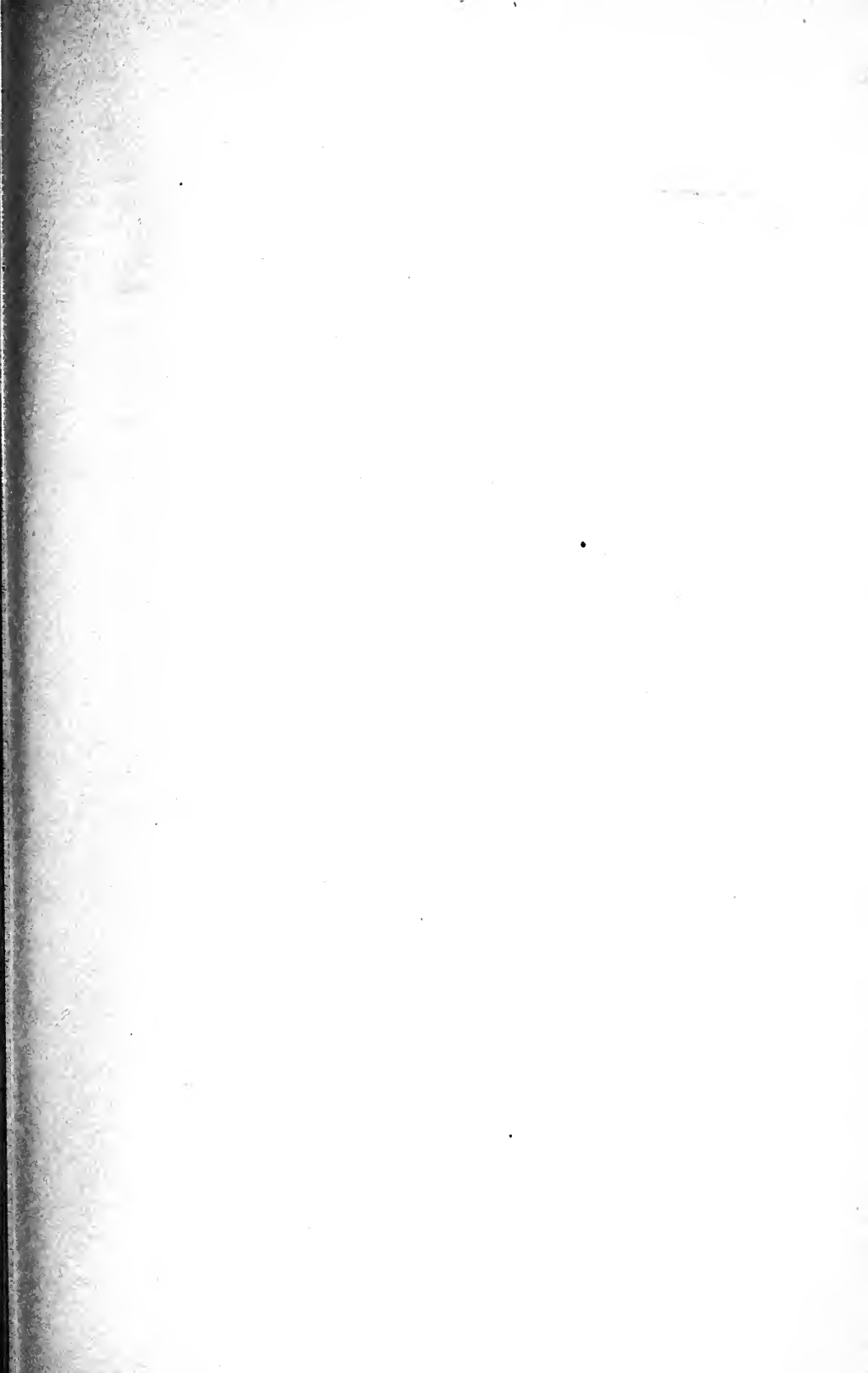
SEPARATION OF METALS. *Method of Fresenius and Babo.*—The solid matter is finely divided and treated with an equal weight of a mixture of pure hydrochloric acid (1 part) and water (3–4 parts). The mixture is then digested on a water-bath and small quantities of potassium chlorate added from time to time. When the solid matter has been entirely decomposed the clear yellow liquid is evaporated, until the odor of chlorine has disappeared, or the chlorine is removed by passing carbon dioxide gas through the solution. The solution is now filtered and examined, by the usual tests, for the metals; in the case of *arsenic*, best after reduction by sulphur dioxide and subsequent warming to remove the excess of the gas.

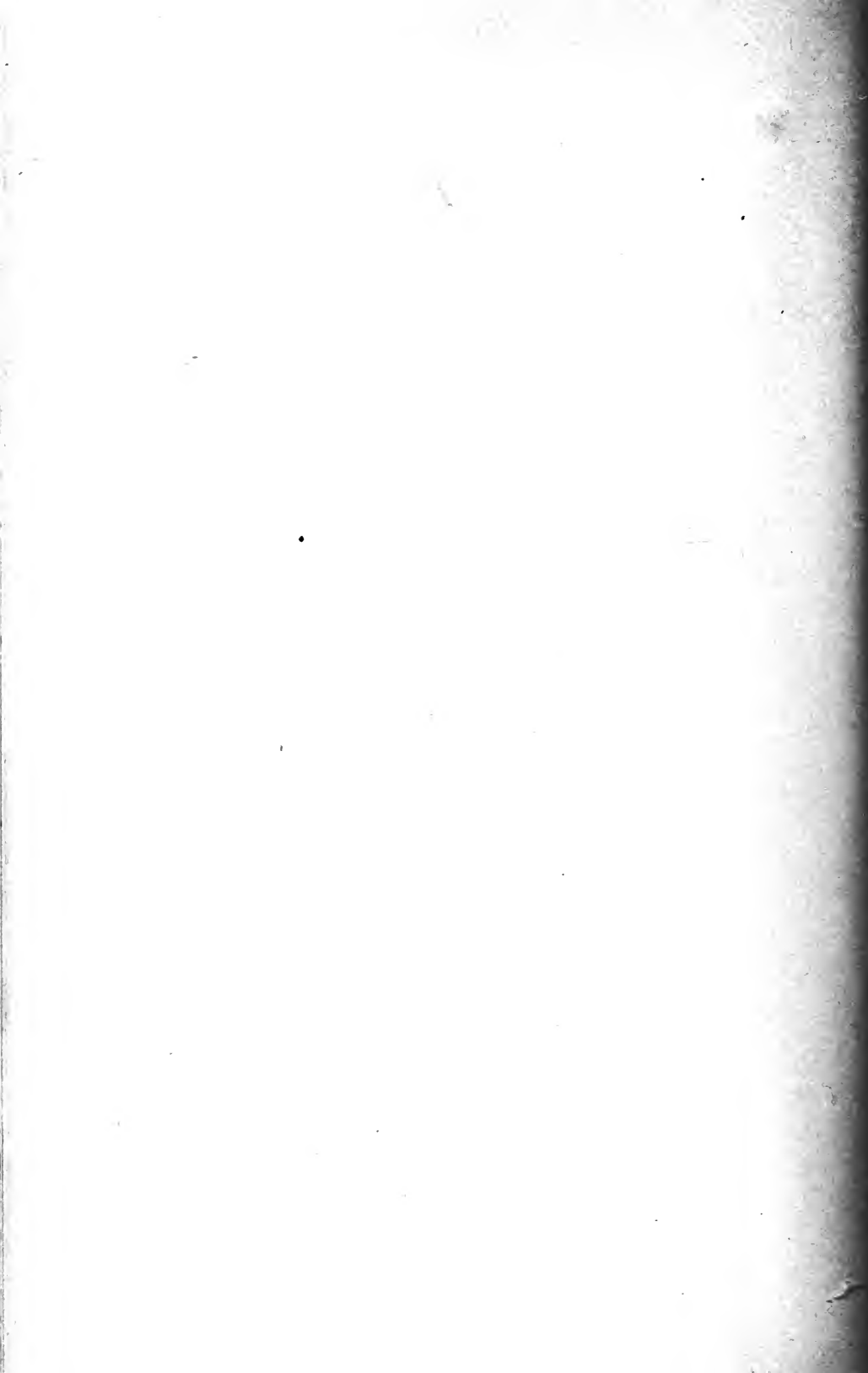
By Distillation.—In the case of arsenic, and of certain volatile compounds of metallic poisons, the following method may be used: The finely divided organic matter is dried on the water-bath, mixed with its own weight of pure hydrochloric acid and distilled from a glass retort provided with a condenser. The distillate is received in cold water, and may be examined at once for poisons.

By Dialysis.—The finely-cut material is digested in cold water—or in dilute acid—for 24 hours, and then placed in a dialyzer. The latter is suspended in a larger vessel containing distilled water, and at the end of another 24 hours the water is evaporated and the residue examined for poisons. This method is applicable also to the separation of the alkaloids.

SEPARATION OF ALKALOIDS, GLUCOSIDES, ETC. The separation of the alkaloids from organic matter is one of the most difficult and, on the whole, one of the most unsatisfactory problems of chemical toxicology. The following outlines will indicate the general nature of the processes used:

Stas-Otto Method.—Treat the finely comminuted mass with twice its weight of pure 90 per cent. alcohol, and with 10 to 30 grains of oxalic acid. Digest at 70° C., and filter. Evaporate the filtrate in vacuo, over sulphuric acid, dissolve the residue in absolute alcohol, filter, and again evaporate at a low temperature. Dissolve in water and extract with ether until all coloring matter is removed, then add sodium carbonate to alkaline reaction, again





agitate with ether, and separate the ethereal layer. Allow the ether to evaporate spontaneously and examine the residue for alkaloids. With the coloring matter the first ethereal extract may contain colchicine, digitalin and picrotoxin. Most of the alkaloids will pass into the second extract, that from the alkaline solution; morphine, however, being nearly insoluble in ether, will remain, and should be examined for by extraction of the alkaline solution with amyl alcohol.

Dragendorff's Method.—This method is convenient, as affording a partial separation of the alkaloids during their extraction. The finely divided substance is digested for several hours with water acidulated with sulphuric acid. The extract is removed and the process repeated, the temperature being maintained at from 40° C. to 50° C. The extracts are united, evaporated to a syrup, and digested with 4 volumes of alcohol for 24 hours at 30° C. The alcoholic extract is filtered, the residue washed with 70 per cent. alcohol, and the united extracts freed from alcohol by evaporation. The aqueous residue, diluted if necessary, is filtered, and the acid liquid, containing the sulphates of the alkaloids, treated with the following reagents:

1.—Agitate with petroleum ether, remove ethereal layer, repeat extraction, evaporate extracts. Residue consists chiefly of *coloring matters*, but may contain, also, *piperine*, *picric acid*, *camphor*, *phenol*, etc.

2.—Extract with benzene. Evaporate extract. Residue, if crystalline, may be *cantharidin*, *santonin*, or *digitalin*, *caffeine*, *piperine*, or *berberine*; if amorphous, *elaterin*, *populin*, *colocynthin*, or *colchicine*.

3.—Extract with chloroform. Evaporate extract. Residue may be *digitalin*, *picrotoxin*, *helleborin*, *saponin*, *cinchonine*, or *theobromine*.

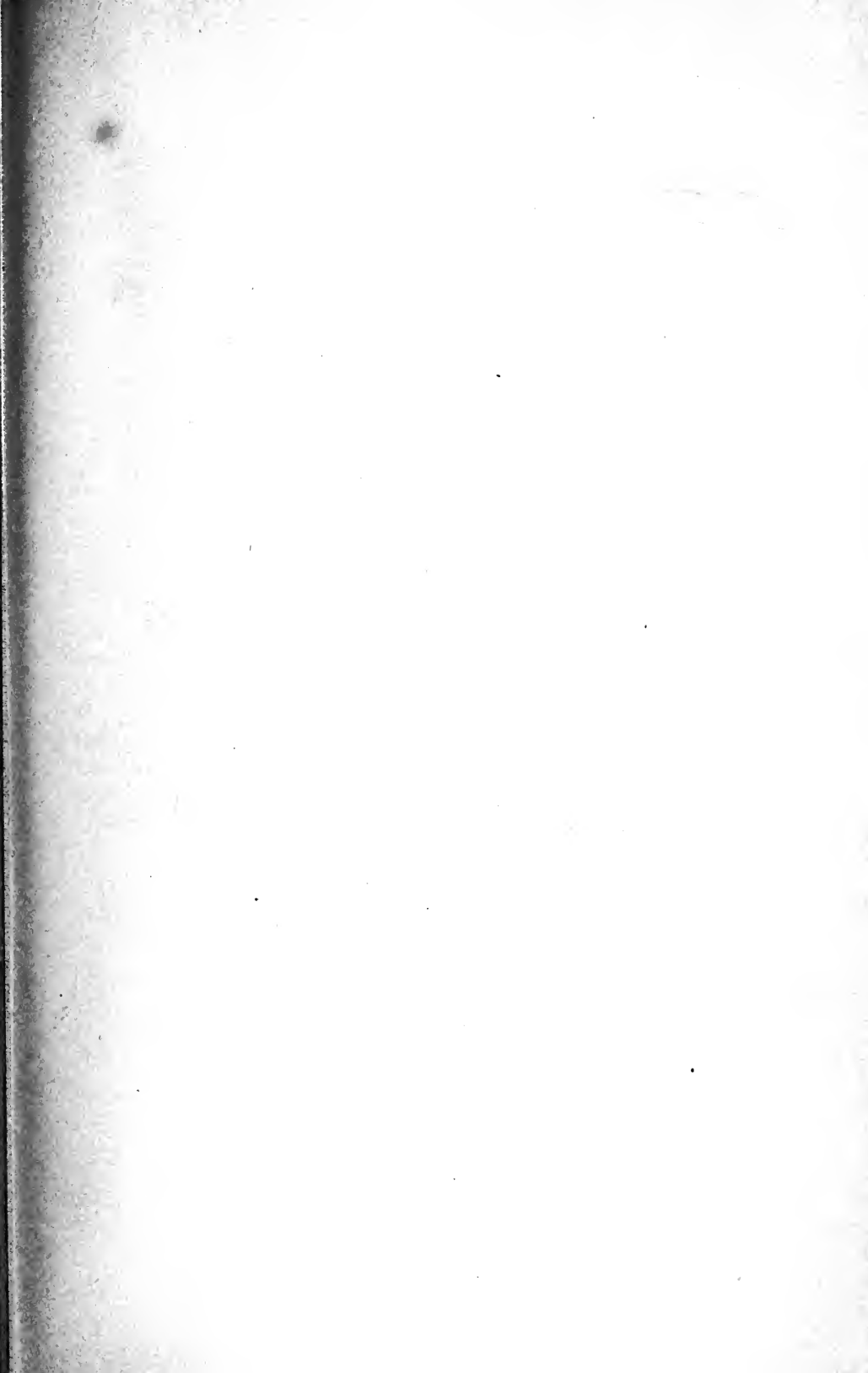
4.—Treat again with petroleum ether, remove ethereal layer, render alkaline with ammonia. Treat the alkaline solution with petroleum ether, remove and evaporate the extract. Residue may be *strychnine*, *quinine*, *brucine*, *veratrine*, *coniine*, *nicotine*, *sparteine*, or *aniline*.

5.—Extract the alkaline solution with benzene. Evaporate extract. Residue may be *strychnine*, *brucine*, *quinine*, *cinchonine*, *atropine*, *hyoscyamine*, *physostigmine*, *aconitine*, *codeine*, *thebaine*, *narceine*, *narcotine*, or *veratrine*.

6.—Extract with chloroform. Evaporate extract. Residue may be *morphine*, *cinchonine*, *papaverine*, or *narceine*.

7.—Extract with amyl alcohol. Evaporate extract. Residue may be *morphine*, *solanine*, or *salicin*.

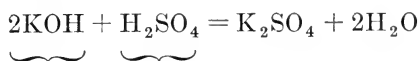
8.—Evaporate remainder of the solution with powdered glass. Extract with chloroform. Evaporate extract. Residue may be *curarine*.



VOLUMETRIC QUANTITATIVE ANALYSIS.

QUANTITATIVE analyses may be conducted by either *gravimetric* or *volumetric* processes. In the former, the constituents are precipitated from solutions by reagents, the precipitates are dried and weighed, and from their weights the composition of the substance is calculated. Volumetric analyses are, as a rule, more quickly performed and require less extensive laboratory appliances. The process, depending on the principle of Definite and Fixed Proportions in chemical combinations, consists in the determination of the amount of a substance in solution by the addition thereto of a reagent of known strength, the *standard solution*. The reagent is added from an accurately graduated glass vessel, known as a *burette*, and the end of the reaction is revealed either by a change in the liquid itself, or by a change in color of a substance added as an *indicator*.

The reaction between sulphuric acid and potassium hydroxide is expressed by the equation:



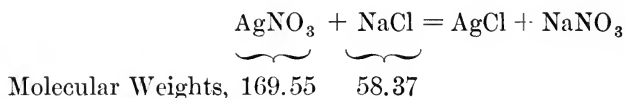
$$\begin{array}{r} \text{* Molecular Weights, } 2)111.98 \quad 2)97.82 \\ \hline \quad \quad \quad 55.99 \quad \quad 48.91 \end{array}$$

If sulphuric acid be added to a solution of potassium hydroxide, the solution will remain alkaline until sufficient acid has been added to complete the above reaction. In other words, to 111.98 parts of potassium hydroxide we must add 97.82 parts of sulphuric acid, in order that complete neutralization shall take place. If more acid be added, the solution will become acid in reaction.

*The equivalents (molecular weights) given in this section are those generally used in the United States by pharmacists. Where more exact values are desired the equivalents may be simply calculated from the list of atomic weights on page 8 of this book.

If 97.82 grammes of sulphuric acid exactly neutralize 111.98 grammes of potassium hydroxide, then if we make a solution containing 98.72 grammes of sulphuric acid in 1000 c.c., each c.c. of this solution will neutralize 0.11198 grammes of potassium hydroxide. So, also, in a solution containing 48.91 grammes of the acid to 1000 c.c., each c.c. will neutralize 0.05599 grammes of the alkali. If now to a solution of potassium hydroxide of unknown strength we add a standard solution of sulphuric acid (one containing a known weight of the acid in each c.c.) until neutralization is effected, we can calculate the amount of alkali from the number of c.c. of acid used.

Again, were we to add a standard solution of sodium chloride to a solution of silver nitrate, the reaction would be expressed by the equation:



The number of c.c. of standard sodium chloride necessary to complete the above reaction (to precipitate all of the silver as silver chloride) affords us the means of calculating the amount of silver nitrate in the solution. The same principle may be applied in other ways, as, for instance, in the determination of the amount of iron in a solution. We may first reduce the iron to the ferrous state by appropriate reducing agents, and then by the addition of a solution of known oxidizing power, we may reconvert the iron to the ferric condition. The number of c.c. of oxidizing solution used, multiplied by the oxidizing power of each c.c., affords the data necessary for the calculation of the iron present.

SOLUTIONS USED.

In order, then, to make a quantitative determination of a substance by a volumetric process, we must have an appropriate reagent, of known strength, a *standard solution*. The strength of this reagent will be determined by the nature of the analysis, but it is convenient that the weight in grammes, dissolved in each litre, shall bear an intimate relation to the molecular weight, thus simplifying subsequent calculations. The solutions most commonly used are designated as Normal, ($\frac{N}{1}$), Deci-Normal, ($\frac{N}{10}$), and Centi-Normal, ($\frac{N}{100}$).

A Normal Solution of a univalent substance contains, in each litre, its molecular weight expressed in grammes.

A Normal Solution of a bivalent substance contains, in each litre, $\frac{1}{2}$ its molecular weight expressed in grammes.

A Normal Solution of a trivalent substance contains, in each litre, $\frac{1}{3}$ its molecular weight expressed in grammes.

A Deci-Normal Solution is $\frac{1}{10}$ th the strength of the corresponding normal solution.

A Centi-Normal Solution is $\frac{1}{100}$ th the strength of the corresponding normal solution.

For example 1 litre of $\frac{N}{1}$ KOH (normal potassium hydroxide) contains 55.99 grammes of KOH. One litre of $\frac{N}{10}$ KOH contains 5.599 grammes of KOH. One litre of $\frac{N}{100}$ KOH contains 0.5599 grammes of KOH. One litre of $\frac{N}{1}$ H_2SO_4 contains 48.91 grammes of H_2SO_4 (molecular weight of bivalent $H_2SO_4 = 97.82$). One litre of $\frac{N}{10}$ H_2SO_4 contains 4.891 grammes of H_2SO_4 , etc.

Indicators.—The success of the volumetric process depends upon the accuracy with which we determine the completion of the chemical reaction between the reagent and the substance under titration. This is generally accomplished by adding to the solution a substance which will reveal by change of color the slightest excess of the reagent. The substance so used is known as an indicator, and must answer to the following conditions: The completion of the test, the end reaction, must be marked by an indisputable change in color; but little of the indicator should be used, and the color change must not be interfered with by any impurities present, nor by the products of the reaction itself. The following are some of the indicators in common use. For their preparation, see Appendix.

Litmus.—Red with acids, blue with alkalies. Litmus is used chiefly in the titration of the mineral acids and alkalies; it is not reliable as an indicator in presence of carbonates, phosphates or arsenates.

Phenolphthalein.—Colorless with acids, red with alkalies. This indicator is much used and is extremely delicate, but its value is lessened by presence of ammonium salts or of borax.

When it is necessary to use phenolphthalein or litmus in presence of carbonic acid (carbonates), the solution under titration should be boiled.

Methyl Orange.—Red with acids, yellow with alkalies. It is not

affected by carbonic anhydride, and hence may be used in presence of carbonates, but it is not satisfactory with organic acids.

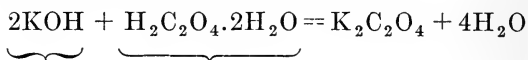
Cochineal.—Yellow with acids, violet with alkalis. Used chiefly with ammonia and ammonium compounds.

Other special indicators will be referred to in describing certain of the processes which follow.

ACIDIMETRY.

The estimation of acids by means of standard alkali solutions. Sodium or potassium hydroxides are the alkalis generally used, the standard solutions being prepared as follows:

Normal Potassium Hydroxide.—If pure potassium hydroxide were obtainable it would only be necessary to dissolve 55.99 grammes of that substance in 1 litre of water. (55.99 being the molecular weight of univalent potassium hydroxide.) It can not be obtained pure, however, owing to its tendency to absorb carbonic anhydride and moisture from the air, and the following U. S. P. method is advised: Dissolve 75 grammes of potassium hydroxide in 1050 c.c. of water at 15° C., and fill a burette with this solution. Dissolve 0.63 grammes of pure crystallized oxalic acid in about 10 c.c. of water and add a few drops of phenolphthalein. Now add the potassium hydroxide, from the burette, until the oxalic acid is just neutralized, a faint pink tint being developed in the solution. Note the number of c.c. of alkali used, and then dilute the remainder of the solution until 10 c.c. will exactly neutralize the 0.63 grammes of oxalic acid. The reaction between the alkali and acid is expressed by the equation:

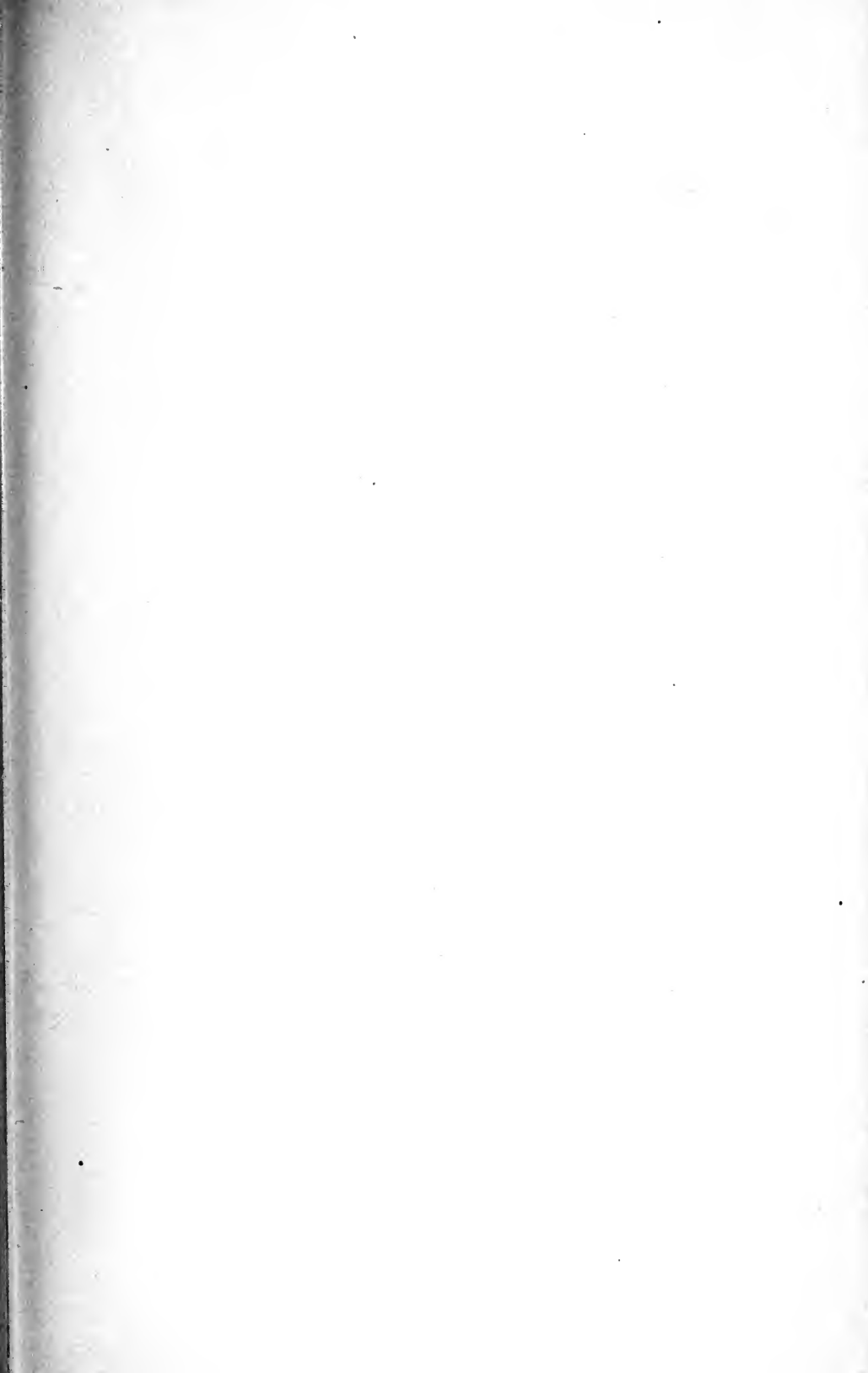


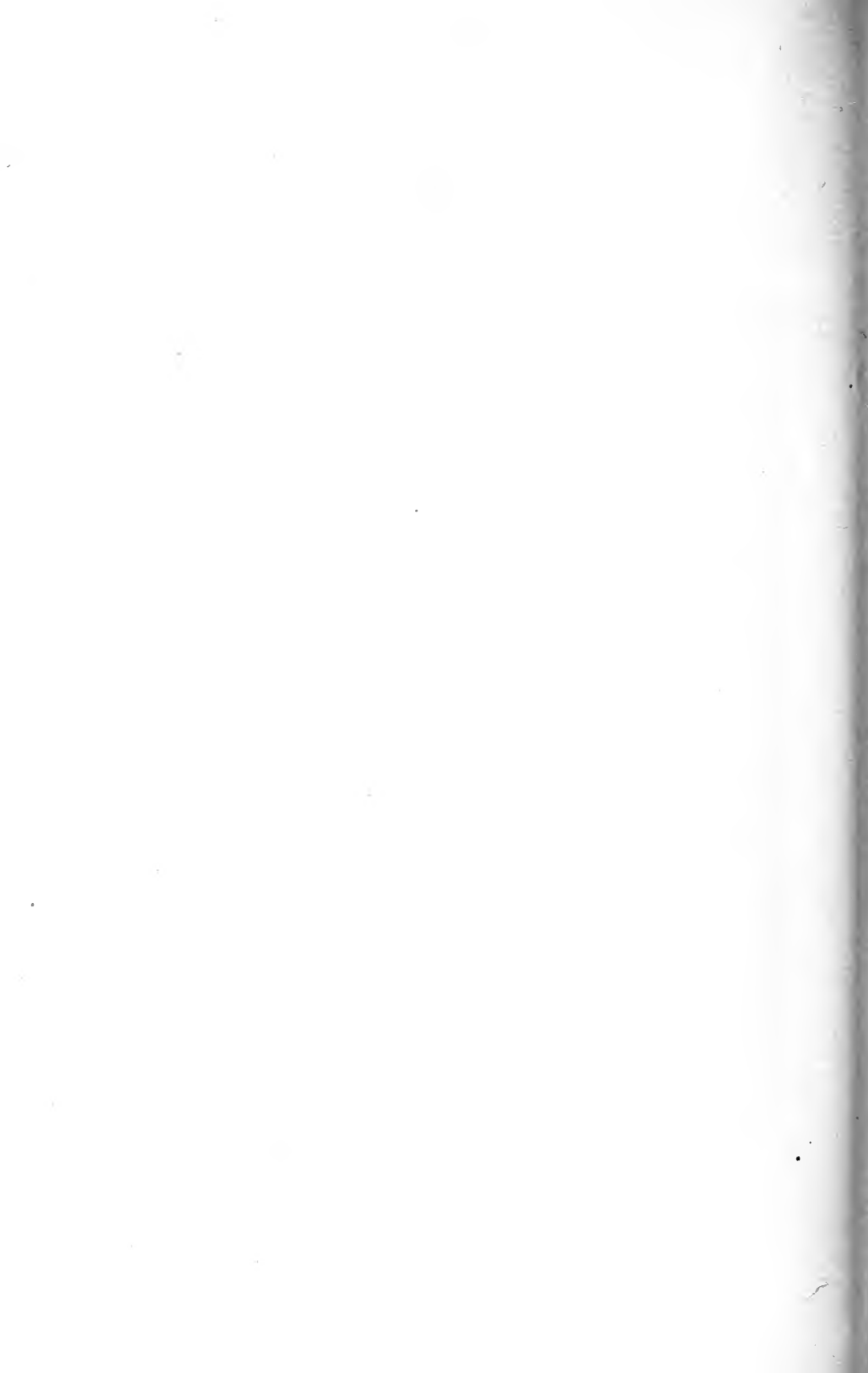
Molecular weights, 112

126

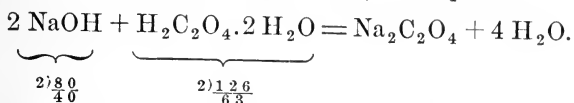
From this it can be seen that 126 parts of oxalic acid are neutralized by 112 parts of potassium hydroxide, or 63 parts by 56 of potassium hydroxide. Normal potassium hydroxide contains 56 grammes to the litre, and 10 c.c. of the normal solution contain 0.56 grammes. Hence, in the preparation of the normal alkali as described, when 10 c.c. exactly neutralizes 0.63 grammes of oxalic acid, then that 10 c.c. must contain 0.56 grammes of potassium hydroxide, and the solution must be normal.

Deci-Normal Potassium Hydroxide.—Dilute 100 c.c. of the normal solution to 1000 c.c., with pure water.





Normal Sodium Hydroxide.—This contains 39.96 (40) grammes of sodium hydroxide to the litre. The solution is prepared by dissolving 54 grammes of sodium hydroxide in 1050 c.c. of water, proceeding, then, exactly as described under potassium hydroxide. The reaction in this case is expressed by the equation:



Each Cubic Centimeter of a Normal Alkali Solution is equivalent to :

Acid,	Grammes.
Acetic, $\text{HC}_2\text{H}_3\text{O}_2$	0.05986
Citric, $\text{H}_3\text{C}_6\text{H}_5\text{O}_7 \cdot \text{H}_2\text{O}$	0.06983
Hydrobromic, HBr	0.08076
Hydrochloric, HCl	0.03637
Hydriodic, HI	0.12753
Lactic, $\text{HC}_3\text{H}_5\text{O}_3$	0.08979
Nitric, HNO_3	0.06289
Oxalic, $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	0.06285
Sulphuric, H_2SO_4	0.04891
Tartaric, $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	0.07482

Method of Analysis.—A weighed quantity of the acid is diluted with a little water, a few drops of phenolphthalein added, and then the standard alkali, from a burette, until a faint pink tint is developed. The number of c.c. of standard solution used, multiplied by the equivalent of each c.c. gives the weight of pure acid in the solution. From this, and the weight of the sample, the percentage may be calculated.

If 5 grammes of hydrochloric acid solution were taken for analysis, and 20 c.c. of normal alkali were required to develop the pink color, then the 5 grammes of acid solution contain, $20 \times 0.03637 = 0.7274$ grammes of pure acid, or, $0.7274 \div 5 \times 100 = 14.55$ per cent.

Remarks.—It is often inconvenient to weigh the sample taken for analysis, and in such a case, a definite *volume* must be used. The titration with the normal solution will give the number of grammes of pure substance in the sample, and for many solutions we can assume the weight of the sample to be equal to as many grammes as there were c.c. taken. (1 c.c. of water weighs 1 gramme.) Or, we can determine the specific gravity of the solu-

tion by means of a hydrometer, and calculate the weight of the sample by multiplying its volume by its specific gravity.

The pharmacopœial practice is to weigh off such a quantity of the substance, for analysis, that the number of c.c. of standard solution used will directly express the percentage sought. Thus, 3.64 grammes of U. S. P. acidum hydrochloricum, containing 31.9 per cent. of pure hydrochloric acid, will be exactly neutralized by 31.9 c.c. of normal alkali. 3.64 grammes of the dilute acid of the Pharmacopœia, containing 10 per cent. of pure acid, will be exactly neutralized by 10 c.c. of normal alkali.

The method is, in general, the same for any acid, merely substituting in the calculation the proper equivalent for each c.c. of the standard alkali used.

ALKALIMETRY.

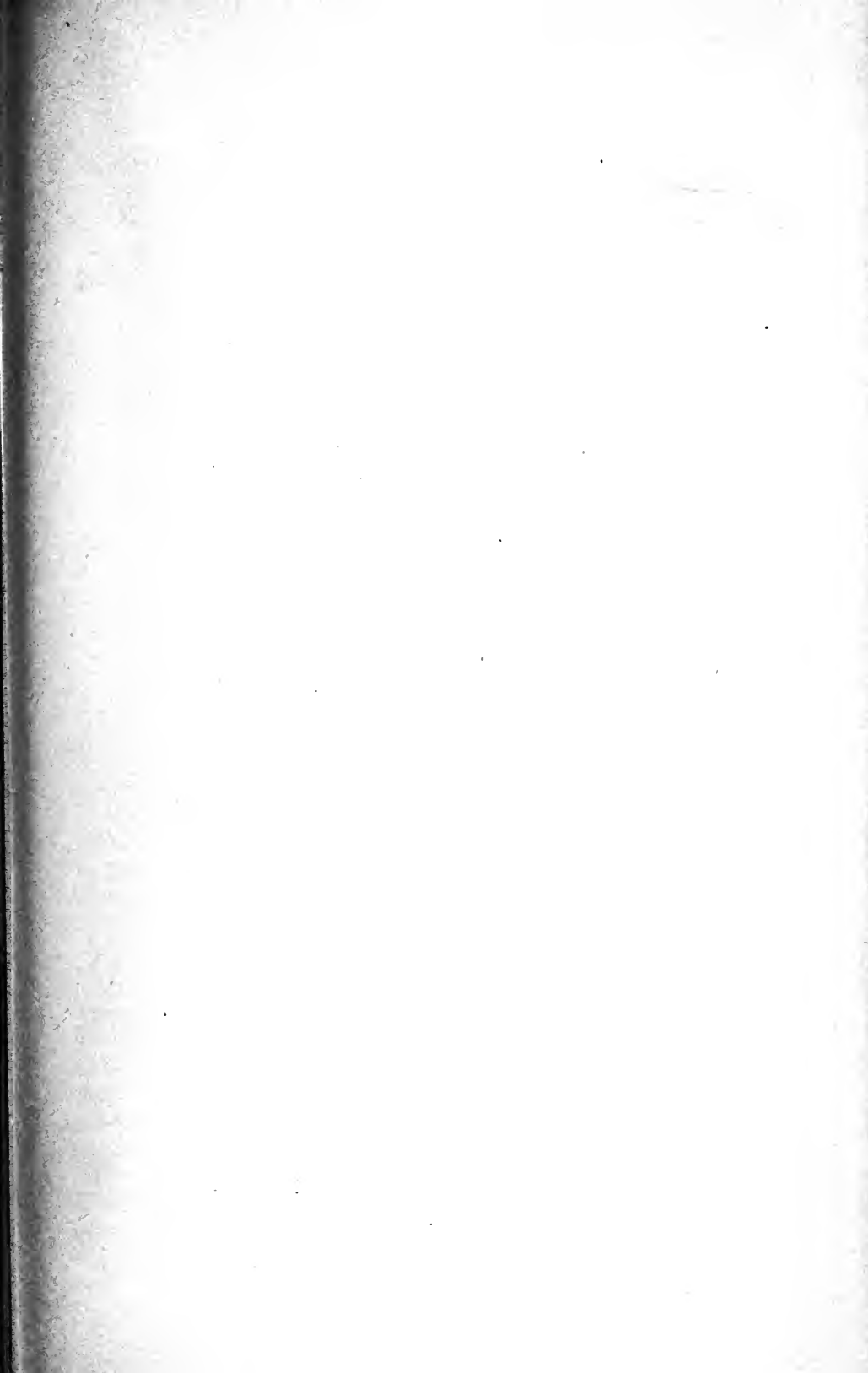
The estimation of alkalies by means of a standard acid solution. Several of the acids are used for this purpose, the more common being oxalic, sulphuric and hydrochloric. Oxalic acid has the distinct advantage over the others of easy preparation, but, as a rule, sulphuric acid will be found to have the widest application and to give the most satisfactory results.

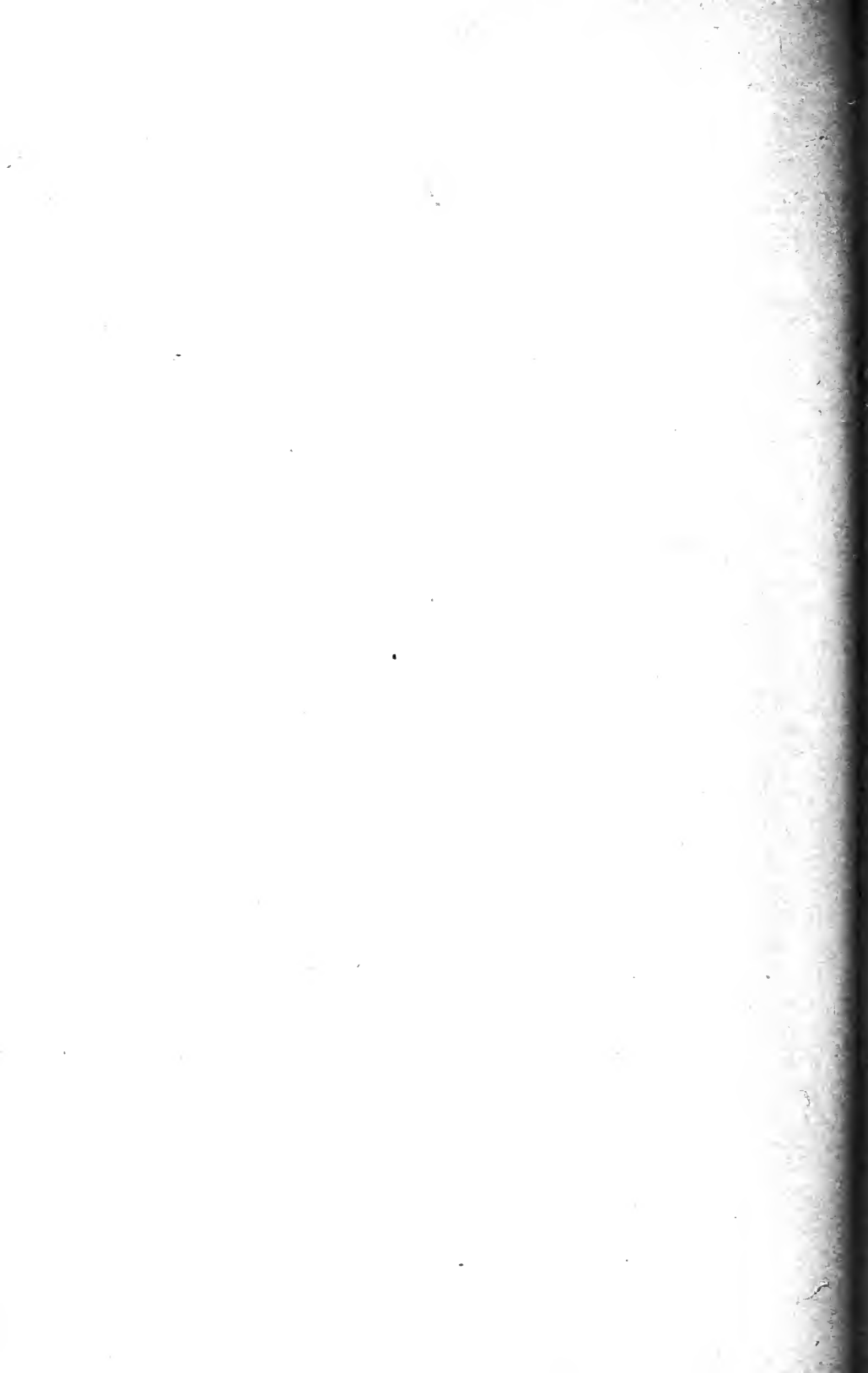
Normal Oxalic Acid.—Dissolve 62.85 grammes of the pure crystalline acid in water and dilute to 1 litre. (62.85 being $\frac{1}{2}$ the molecular weight of the bivalent, crystalline oxalic acid.)

Deci-Normal Oxalic Acid.—Dilute 100 c.c. of the normal acid to 1000 c.c. with water; or, dissolve 6.285 grammes of the acid in water and dilute to 1 litre.

Centi-Normal Oxalic Acid.—Dilute 10 c.c. of the normal acid to 1000 c.c. with water; or, dissolve 0.6285 grammes of the acid in water and dilute to 1 litre.

Normal Sulphuric Acid.—The normal solution of sulphuric acid contains 48.91 grammes in 1 litre. (48.91 being $\frac{1}{2}$ the molecular weight of the bivalent acid.) It is prepared by mixing 30 c.c. of pure concentrated acid, specific gravity 1.835, with enough water to make 1050 c.c. The mixture is cooled, and its strength determined by titration with normal potassium hydroxide. It is then diluted with water until 10 c.c. will exactly neutralize 10 c.c. of the normal alkali; in other words, until each c.c. contains 0.04891 grammes of pure sulphuric acid.





Each Cubic Centimeter of a Normal Acid Solution is equivalent to :

	Grammes.
Ammonia gas, NH_3	0.01701
Ammonium hydroxide, NH_4OH	0.03497
Lithium carbonate, Li_2CO_3	0.03693
Potassium bicarbonate, KHCO_3	0.09988
Potassium carbonate, K_2CO_3	0.06895
Potassium hydroxide, KOH	0.05599
Sodium bicarbonate, NaHCO_3	0.08385
Sodium carbonate, Na_2CO_3	0.05292
Sodium hydroxide, NaOH	0.03996

Method of Analysis.—A weighed quantity of the sample is diluted with water, or, if solid, is dissolved in water, a few drops of phenolphthalein added, and the standard acid run in from a burette until the pink color of the solution is just destroyed. The number of c.c. of standard acid used, multiplied by the equivalent of each c.c., gives the weight of pure alkali in the solution. From this, and the weight of the sample, the percentage can be calculated.

If 5 grammes of sodium hydroxide solution were taken for analysis, and 25 c.c. of normal sulphuric acid were required to effect neutralization, then the 5 grammes of alkali solution contain $25 \times 0.03996 = 0.999$ grammes of pure sodium hydroxide, or, $0.999 \div 5 \times 100 = 19.98$ per cent.

Remarks.—In the titration of carbonates, methyl orange is to be used as the indicator, the standard acid being added until the solution acquires a faint orange-red tint. Otherwise the process is as described. The remarks on p. 61 are also applicable here.

ESTIMATION OF HALOID SALTS.

Salts of chlorine, bromine and iodine, may be conveniently estimated by precipitation with a standard solution of silver nitrate. The reagent is added until all of the halogen has been precipitated as silver salt, and from the number of c.c. used the original halogen compound may be calculated. The completion of the reaction may be determined by testing small portions of the solution from time to time, filtering off the precipitate and adding a drop of silver nitrate, until no further precipitation occurs. Much more satisfactorily, however, we can add to the solution a few drops of potassium chromate, which, by formation of red silver

chromate when all of the halogen has been precipitated, will reveal the slightest excess of the silver nitrate.

Deci-Normal Silver Nitrate.—Dissolve 16.955 grammes of pure silver nitrate in water and dilute to 1 litre, at 15° C. (The molecular weight of silver nitrate being 169.55, the deci-normal solution will contain $\frac{1}{10}$ th of the molecular weight, expressed in grammes.) The solution should be kept in the dark.

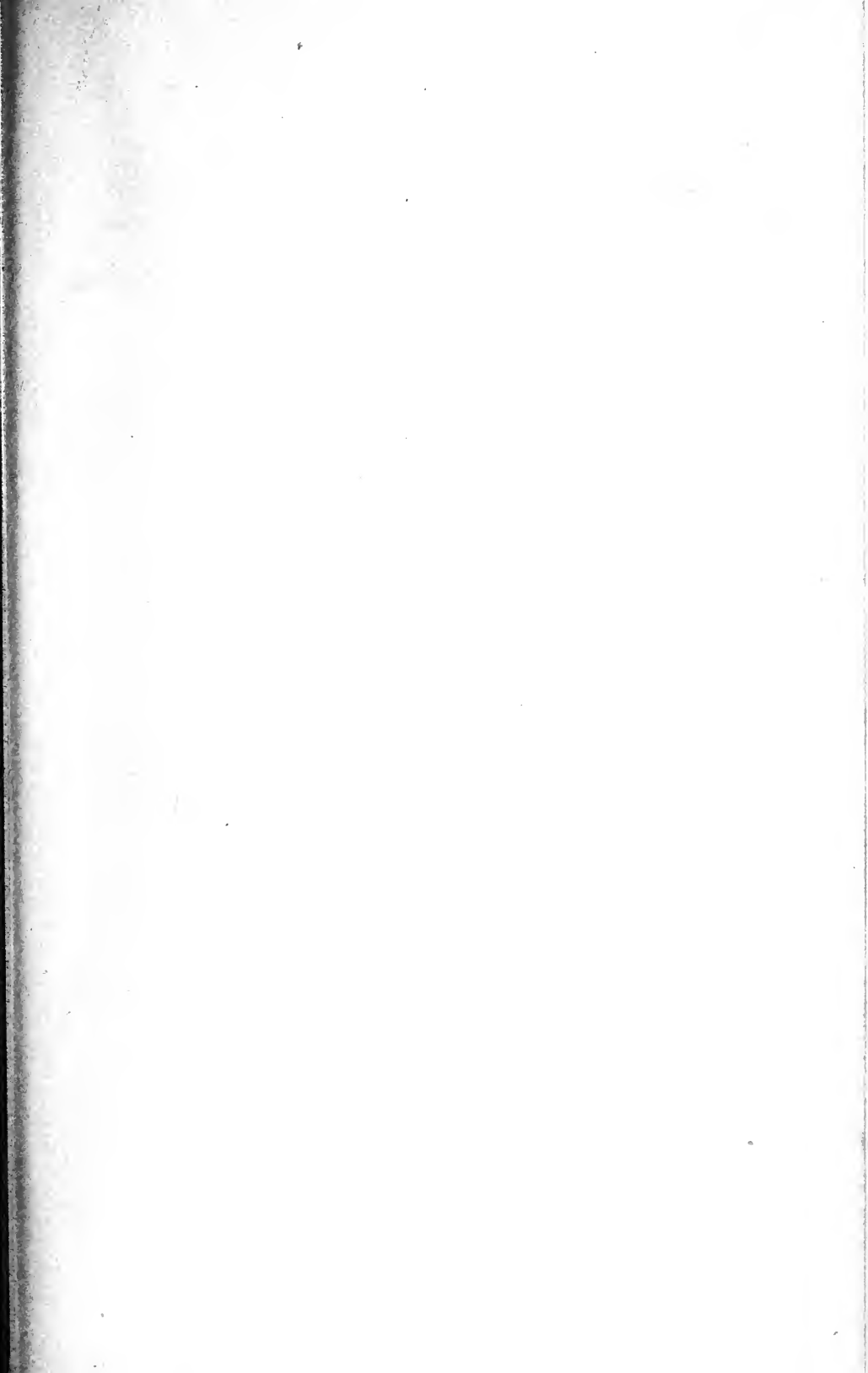
Should pure silver nitrate not be available, a trial solution stronger than the deci-normal is first prepared, and then 0.1167 grammes of pure sodium chloride is dissolved in water and titrated. Were the silver nitrate deci-normal, 20 c.c. would exactly precipitate all of the chlorine of the salt as silver chloride; but as the solution is stronger than deci-normal, less than 20 c.c. will complete the reaction. Determine the exact strength of the strong silver nitrate and dilute with such a quantity of water as will reduce it to the strength required, *i. e.*, to the deci-normal.

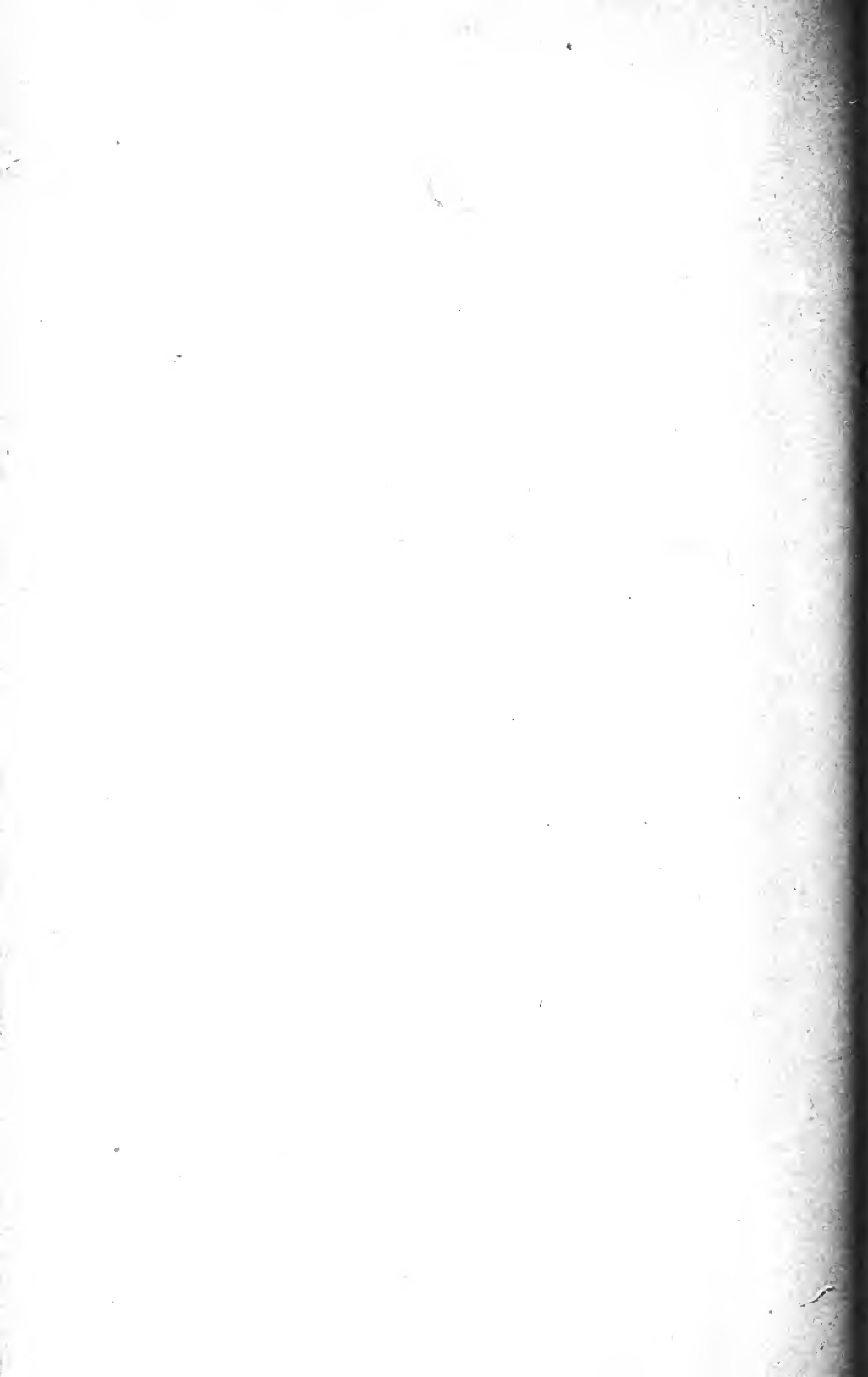
Each Cubic Centimeter of Deci-Normal Silver Nitrate Solution is equivalent to:

	Grammes.
Ammonium Bromide, NH_4Br	0.009777
Chlorine, Cl	0.003537
Lithium Bromide, LiBr	0.008677
Potassium Bromide, KBr	0.011879
Potassium Chloride, KCl	0.007440
Potassium Cyanide, KCN	0.013002
Potassium Iodide, KI	0.016556
Sodium Bromide, NaBr	0.010276
Sodium Chloride, NaCl	0.005837
Zinc Chloride, ZnCl_2	0.006792

Method of Analysis.—To a measured volume of the salt solution, or to a weighed quantity of the salt dissolved in water, add a few drops of neutral potassium chromate, and then the deci-normal silver nitrate, from a burette, until the solution acquires a slight but permanent red tinge. The number of c.c. of the deci-normal solution used, multiplied by the equivalent of each c.c., gives the weight of the halogen salt in solution. From this and the weight of the sample, the percentage strength can be calculated.

In titrating potassium cyanide, no indicator is used, but the silver nitrate is added until the appearance of the first, slight, permanent precipitate.





ESTIMATION OF ALKALOIDS.

By Mayer's Solution.—(See Appendix.) The weighed alkaloid is dissolved in water acidulated with sulphuric acid and the Mayer's solution added from a burette until all is precipitated. Alcohol, acetic acid, and ammonia all interfere with the test, but the results, at the best, are only approximate. Each c.c. of the solution will precipitate the following weights of the alkaloids:

Grammes.	Grammes.
Aconitine0.0269	Coniine.....0.0125
Atropine0.0090	Morphine.....0.0200
Brucine0.0197	Nicotine.....0.0040
Cinchonine0.0102	Quinine0.0108
Cocaine0.0151	Sparteine .. .0.0028
Codeine0.0149	Strychnine0.0167

By Standard Acid and Alkali Solutions.—The free alkaloid is dissolved in a measured amount of $\frac{N}{20}$ HCl, and the excess of acid, over that which combines with the alkaloid, determined by titration with $\frac{N}{20}$ NaOH, using phenolphthalein as the indicator.

The following direct method may also be employed: Dissolve the alkaloid in a little chloroform, add a few c.c. of water, and then titrate with $\frac{N}{20}$ HCl, using methyl orange as the indicator, and agitating after each addition of acid.

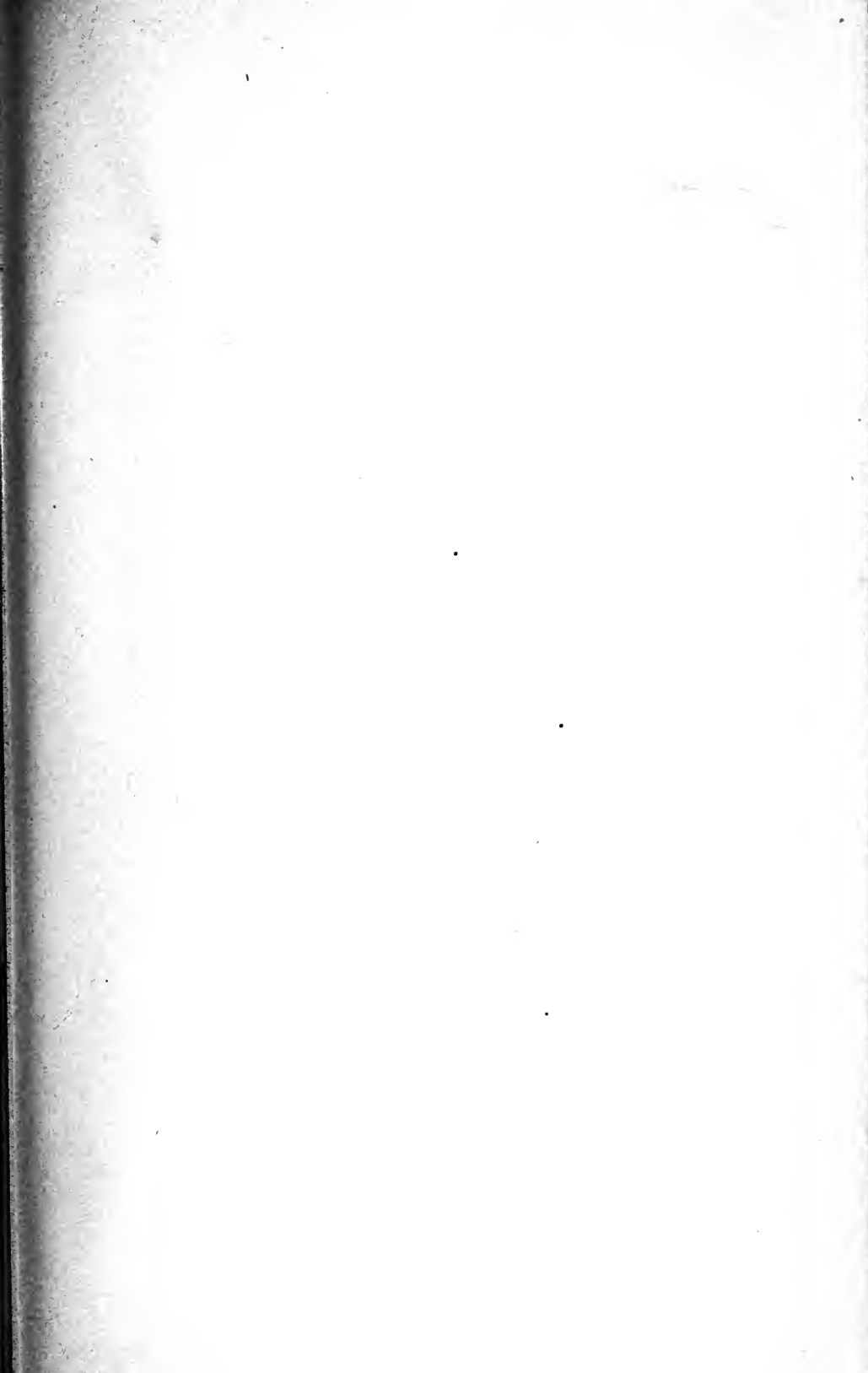
Salts of the alkaloids may be titrated directly with $\frac{N}{20}$ NaOH, using either phenolphthalein or methyl orange as an indicator.

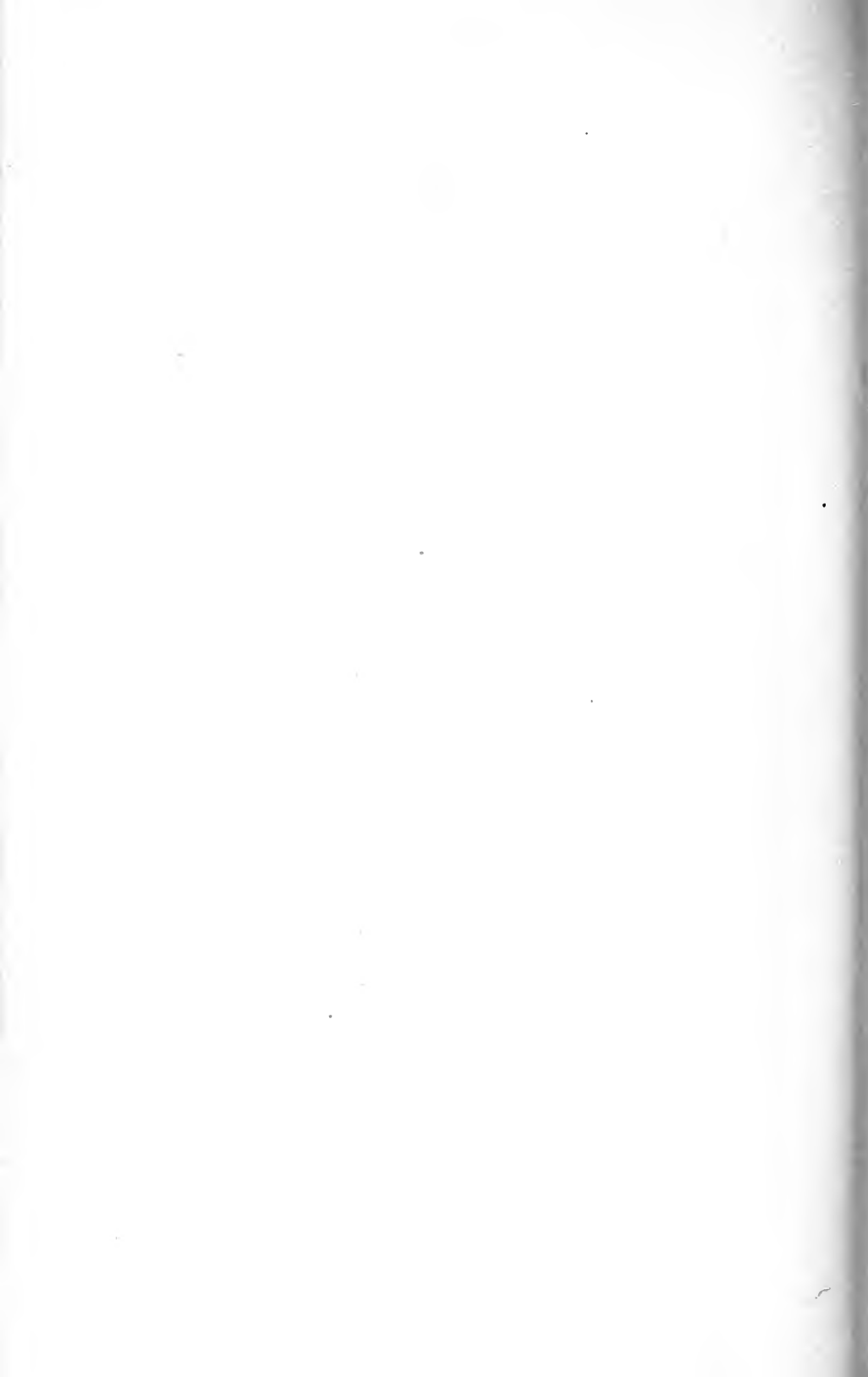
Each c.c. of the $\frac{N}{20}$ acid or alkali is, theoretically, equivalent to:

Grammes.	Grammes.
Aconitine0.0323	Coniine.....0.0062
Atropine0.0144	Morphine0.0142
Brucine0.0197	Nicotine0.0040
Cinchonine0.0147	Quinine0.0162
Cocaine0.0151	Sparteine0.0028
Codeine0.0149	Strychnine.....0.0167
* * *	* * *

Special Volumetric Processes, applicable in urine analysis, in the analysis of the gastric fluid, water, etc., are described in the clinical section of this book.

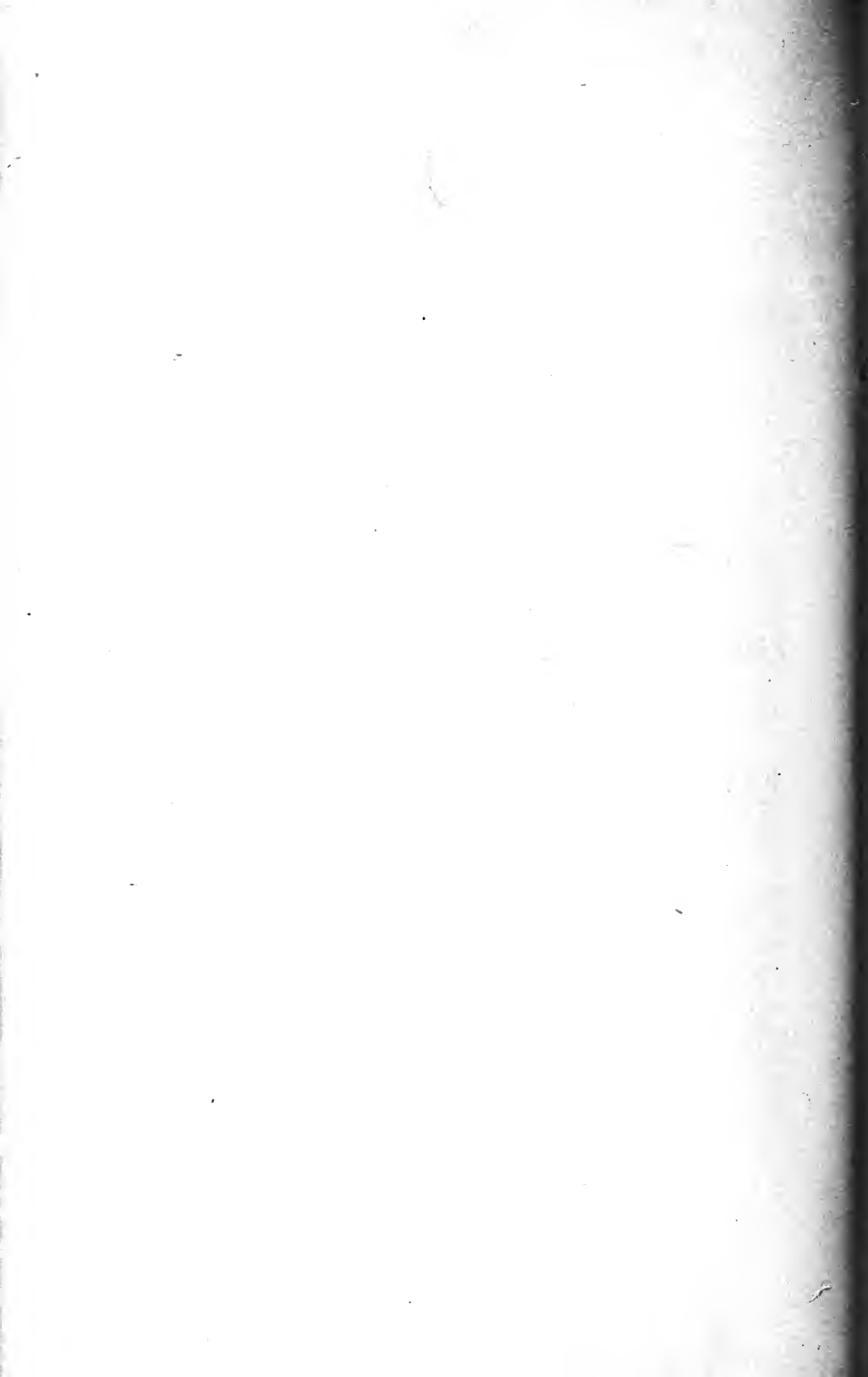


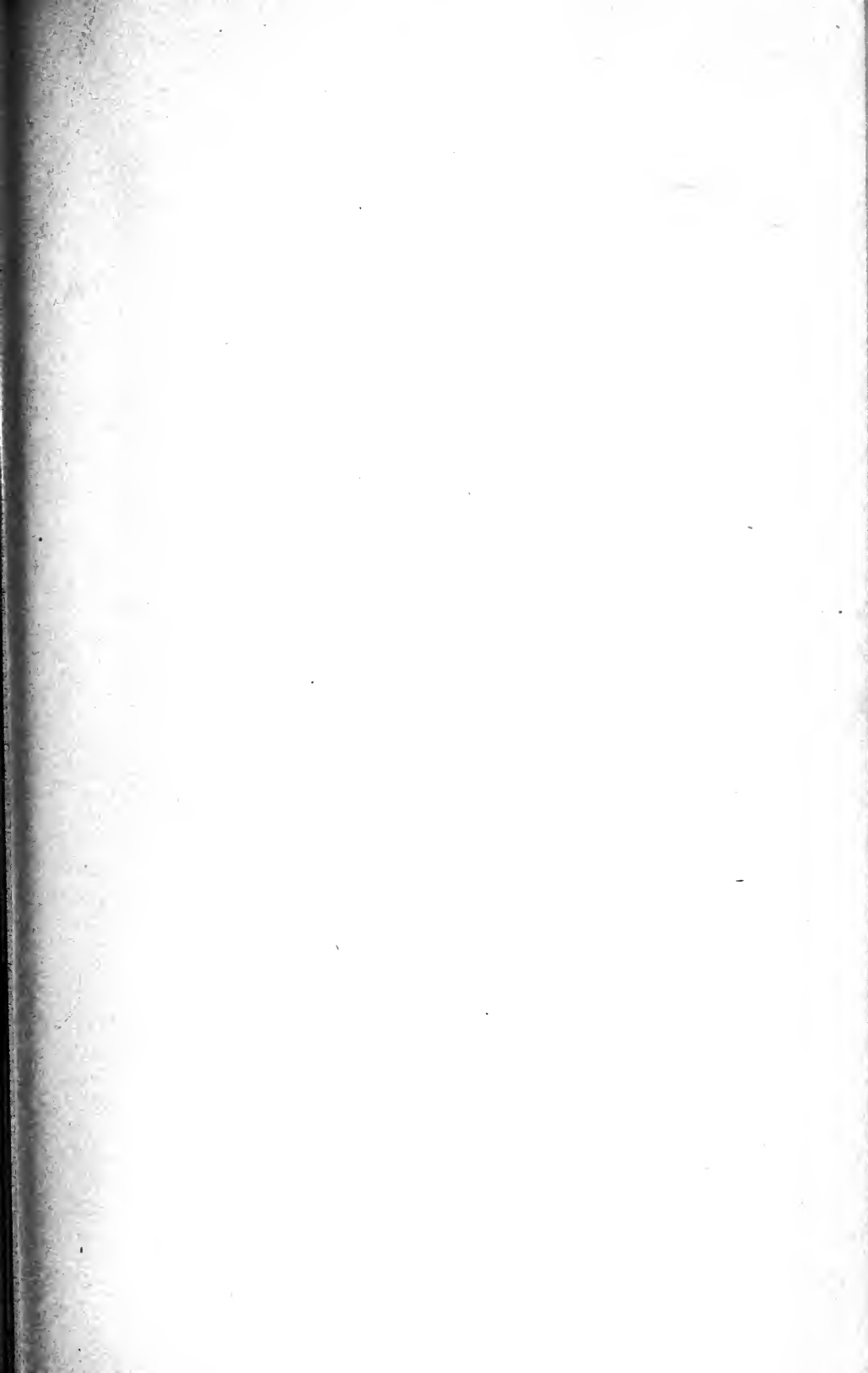


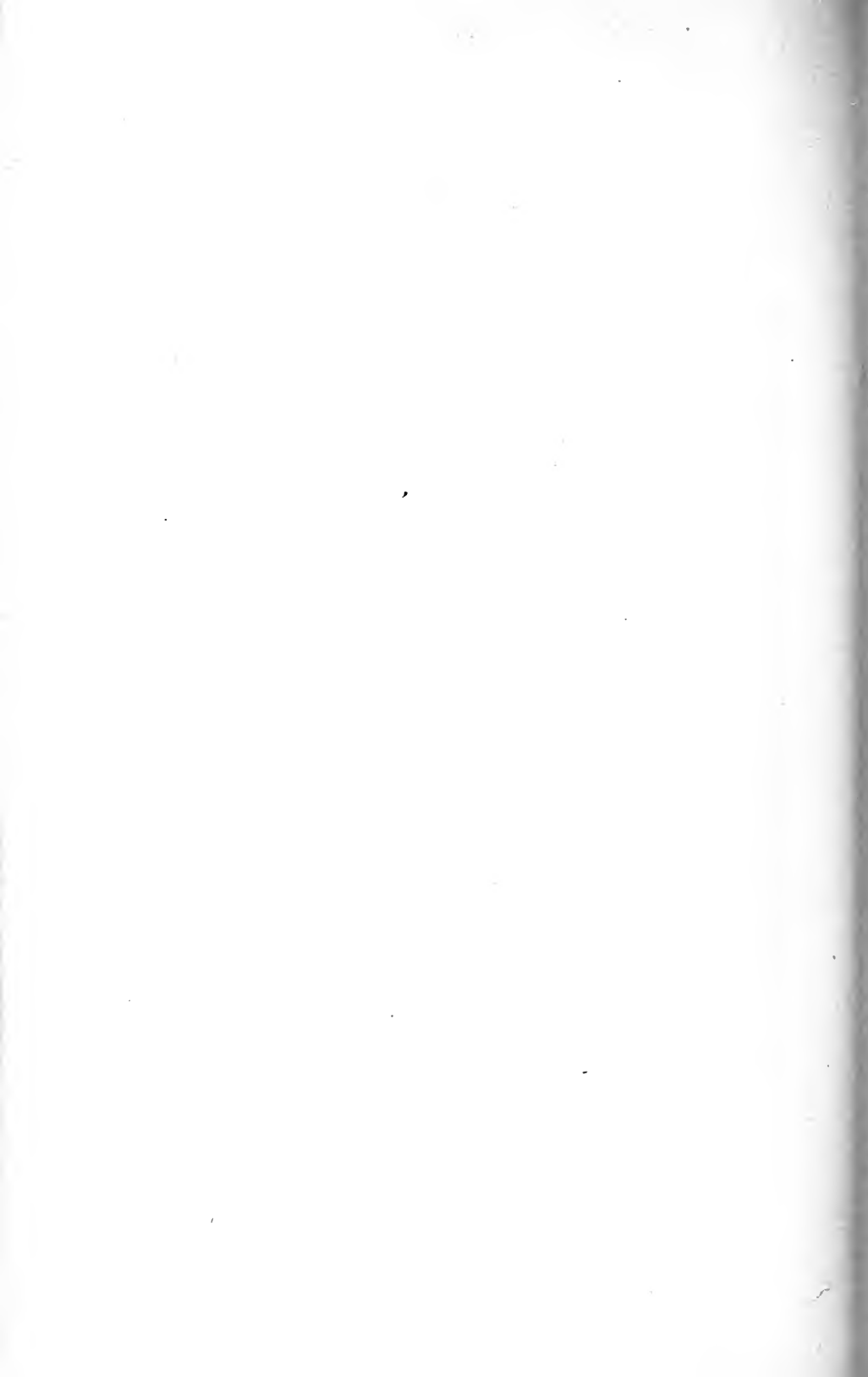


PART II.

THE CARBOHYDRATES, PROTEIDS,
AND FATS,
FERMENTS AND FERMENTATION.







THE CARBOHYDRATES.

THE carbohydrates, an important group of compounds, are chiefly of vegetable origin, but occur, also, in the animal tissues and fluids. They may be classified as follows:

<i>Monosaccharids,</i> <i>or Glucoses.</i>	<i>Disaccharids,</i> <i>or Sucroses.</i>	<i>Polysaccharids,</i> <i>or Amyloses.</i>
$C_6H_{12}O_6$.	$C_{12}H_{22}O_{11}$.	$(C_6H_{10}O_5)_n$.
Dextrose (Glucose),	Sucrose (Cane Sugar),	Cellulose,
Levulose (Fruit Sugar),	Lactose (Milk Sugar),	Starch,
Galactose,	Maltose,	Granulose,
Mannose,	Mycose,	Dextrin,
Sorbose.	Raffinose.	Glycogen.

Chemically the glucoses may be considered as aldehydes and ketones derived from hexatomic alcohols. The amyloses and sucroses may be regarded as anhydrides of the glucoses.

By oxidation carbohydrates are converted into mannitic acid, and, by further oxidation, into mucic and saccharic acids, tartaric acid, oxalic acid and carbonic acid. By oxidation in presence of an alkali, carbohydrates are converted into glucic and melassic acids.

DEXTROSE. (Glucose, Grape Sugar, etc.)

A white powder, more or less crystalline, soluble in water, less soluble in alcohol, insoluble in ether. It is sweet to the taste, but less so than cane sugar. This sugar is found in fruits, in honey, and, in small amount, in the various fluids of the body. In diseased conditions it may appear in the body fluids in largely increased amount.

1.—*Moore's Test*.—Add to a dilute solution of glucose one-half volume of sodium hydroxide, and heat to boiling. A brown coloration is obtained. Add a little nitric acid, the color disappears in part and the characteristic odor of caramel is given off.

2.—*Picric Acid Test*.—Add to the solution a few drops of picric acid and a little sodium hydroxide. Heat the mixture and a mahogany-brown color is developed.

3.—*Silver Test*.—To some ammonio-silver nitrate add a few grains of glucose. When dissolved, heat to boiling. The solution turns dark and a metallic mirror of silver is formed at the bottom of the tube. Tartaric acid and aldehyde each give the same test.

4.—*Fermentation Test*.—To the solution in a test-tube add a small piece of dry yeast and invert the tube over mercury. After standing for 24 hours in a warm place, carbonic anhydride gas will be found to have accumulated at the top of the tube. The liquid may be tested for alcohol. It is well to make a control test with yeast and pure water in a second test-tube.

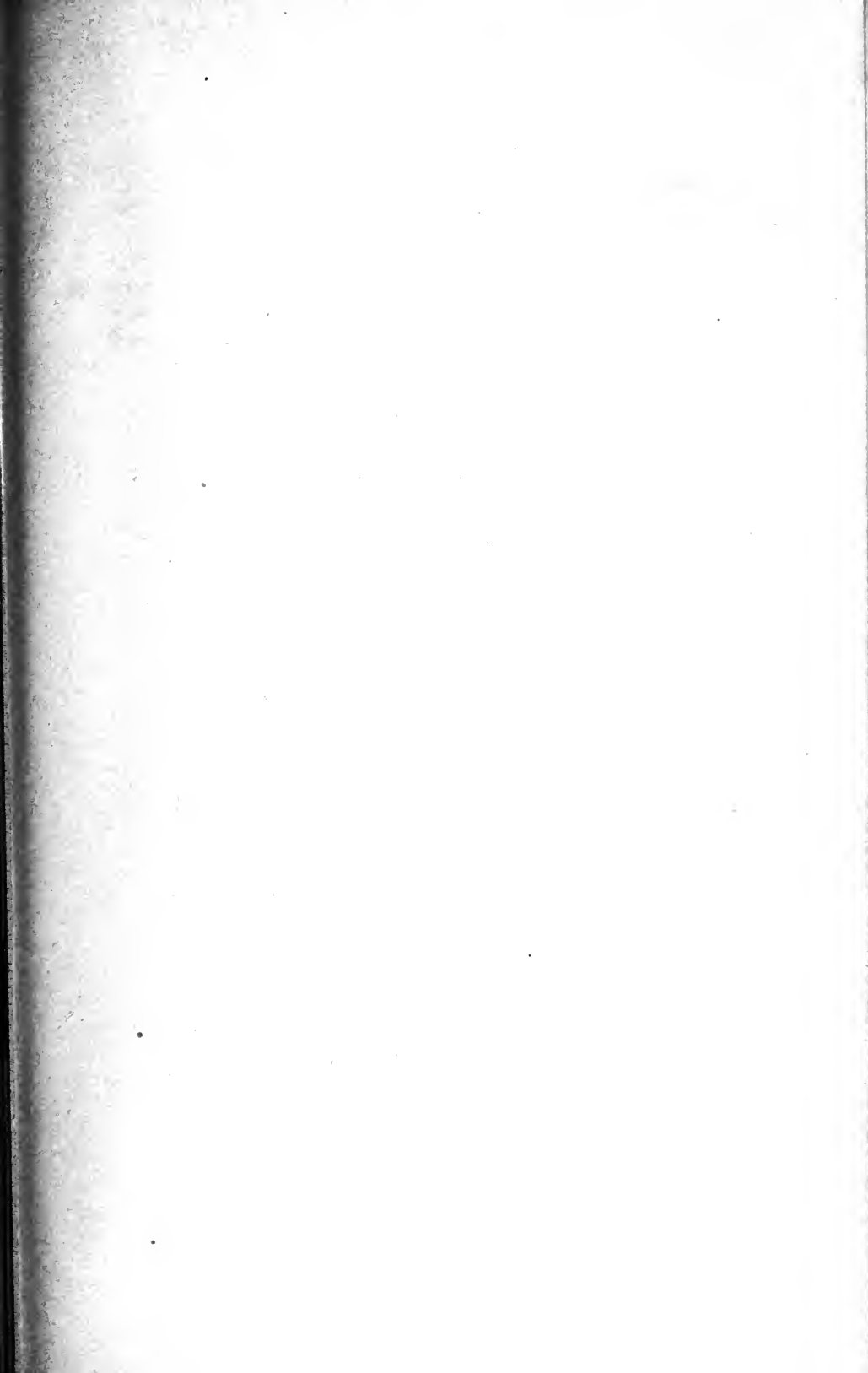
5.—*Böttger's Test*.—To the solution of glucose in a test-tube add sodium hydroxide and then a few grains of bismuth subnitrate. Mix the solution well and heat to boiling. A black precipitate of metallic bismuth is formed. Sodium carbonate may be used in place of sodium hydroxide.

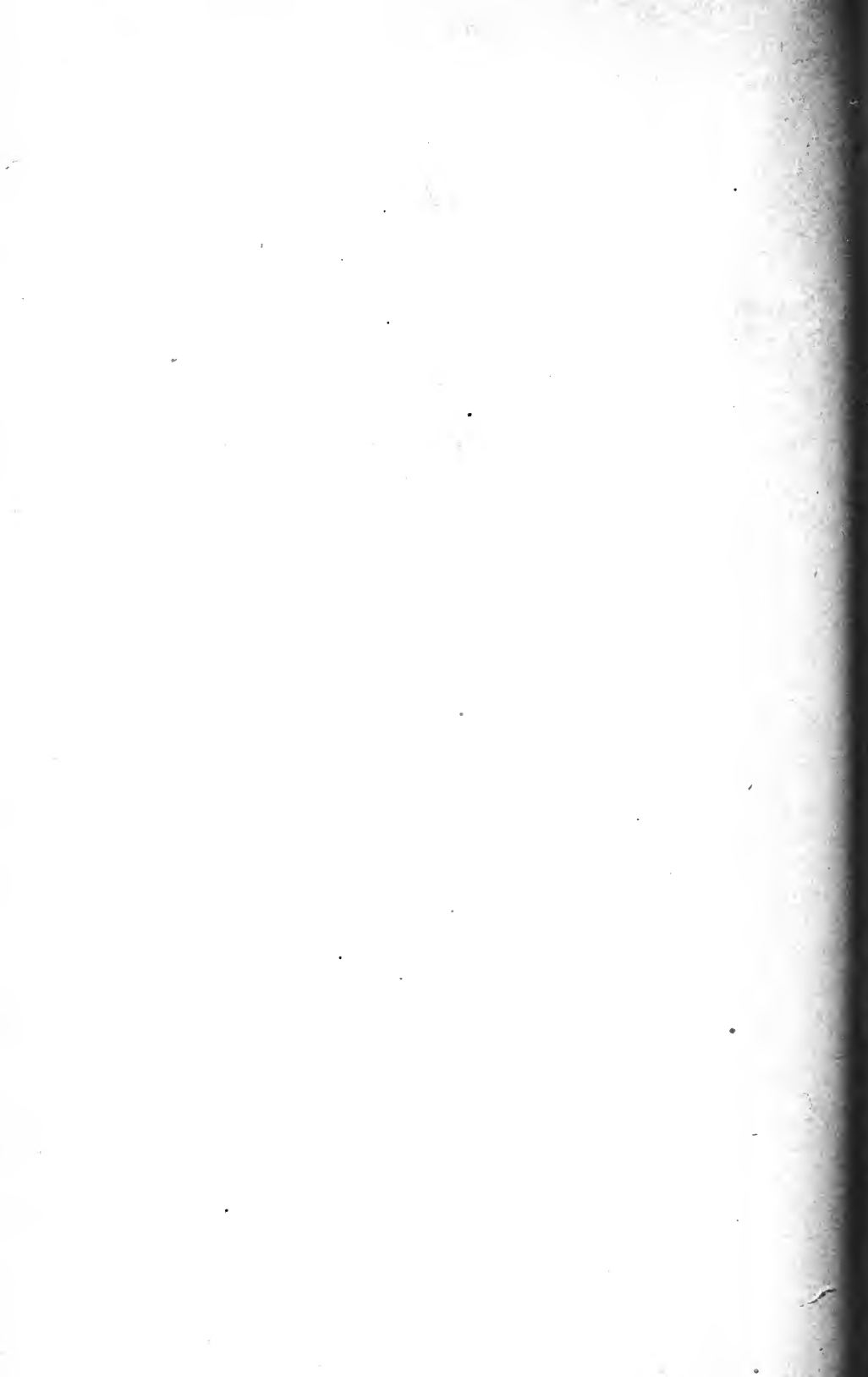
6.—*Trommer's Test*.—To the solution add an excess of sodium hydroxide, and then a solution of copper sulphate drop by drop, until a slight permanent precipitate is formed. In the presence of glucose the bluish-white precipitate of cupric hydroxide first formed dissolves on agitation, producing a dark blue solution. Heat the liquid and, in presence of glucose, yellow cuprous hydroxide and red cuprous oxide are precipitated just as the liquid begins to boil. The same precipitation occurs, but much more slowly, in the cold.

7.—*Fehling's Test*.—Heat a little diluted Fehling's solution (see Appendix) to boiling in a test-tube, and add, drop by drop, the solution to be tested. The presence of glucose will be indicated by the production of a yellowish-red precipitate.

Various modifications of Fehling's Test have been proposed, among them *Pavy's* and *Purdy's Ammoniacal Copper Tests*, depending upon the decolorization of the solution instead of upon the production of the red precipitate, *Haine's Test*, *Loewe's Test*, *Schmiedeberg's Test*, etc. Formulæ for Pavy's, Purdy's and Haine's solutions are given in the Appendix, and Purdy's and Haine's tests are described with the tests for glucose in the urine.

8.—*Indigo-Carmine Test*.—Add sodium carbonate to the solution, to render it alkaline, and then add sufficient indigo-carmine solution to impart a blue color. Boil, and the solution turns first





violet, then yellow, but the blue color may be restored by agitation with air.

9.—*Phenylhydrazin Test*.—Add to the solution two grammes of phenylhydrazin hydrochloride, and four grammes of sodium acetate. Dissolve the salts by agitation and warm on the water-bath for 45 minutes. If glucose be present, on cooling, if not before, a yellow crystalline precipitate of glucosazone will separate out.

10.—*Alpha-naphthol Test*.—Add to the liquid a saturated solution of alpha-naphthol and an excess of sulphuric acid. In presence of glucose (and of other sugars) a violet color is developed. The addition of water causes a blue precipitate to form, soluble in alcohol, ether, and sodium hydroxide, with the production of a yellow solution.

11.—*Barfoed's Test*.—Boiled with Barfoed's reagent (see Appendix) solutions of glucose cause a precipitation of red cuprous oxide.

For the detection of glucose in the urine, and for the quantitative estimation of glucose, see under Urine Analysis.

LEVULOSE AND GALACTOSE.

Levulose is very similar to dextrose, differing from it principally in its action on polarized light, being lævo-rotatory while dextrose is dextro-rotatory. It is less easily crystallized and, in the body, occurs only in traces. Chemical tests are the same as for dextrose.

Invert Sugar is a mixture of dextrose and levulose obtained by the action of acids and of certain ferments on cane sugar.

Galactose is formed by the action of acids and of ferments on lactose. It resembles dextrose closely.

SUCROSE. (Cane Sugar.)

A white crystalline solid, easily soluble in water, insoluble in absolute alcohol and in ether. It occurs in large amount in sugar cane, beet root, maple sap, etc.

1.—To a little sugar in a test-tube add sulphuric acid and warm gently. The sugar is charred.

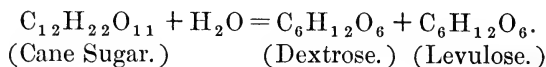
2.—Heat some sugar on a piece of platinum foil. It melts, darkens, chars, and burns, giving off inflammable gases and the characteristic odor of caramel.

3.—To a solution of sugar add a little sodium hydroxide and warm. If the sugar be pure there will be no change of color. (Compare with Dextrose.)

4.—Warmed with nitric acid, sugar is converted into saccharic, tartaric, and, finally, oxalic acid, red fumes of nitrogen oxides being evolved. A similar reaction is given with other carbohydrates, and, also, with arsenious oxide.

5.—Cane sugar does not reduce Fehling's Solution ; with Trommer's Test a blue solution is obtained, but there is no reduction, except by prolonged boiling, when a slight precipitation may occur with either Fehling's or Trommer's.

6.—By the action of yeast and, also, by boiling with dilute acids, cane sugar is converted into dextrose and levulose. To a dilute solution of sugar, add a little hydrochloric acid and boil for several minutes. Cool the solution and apply Trommer's Test.



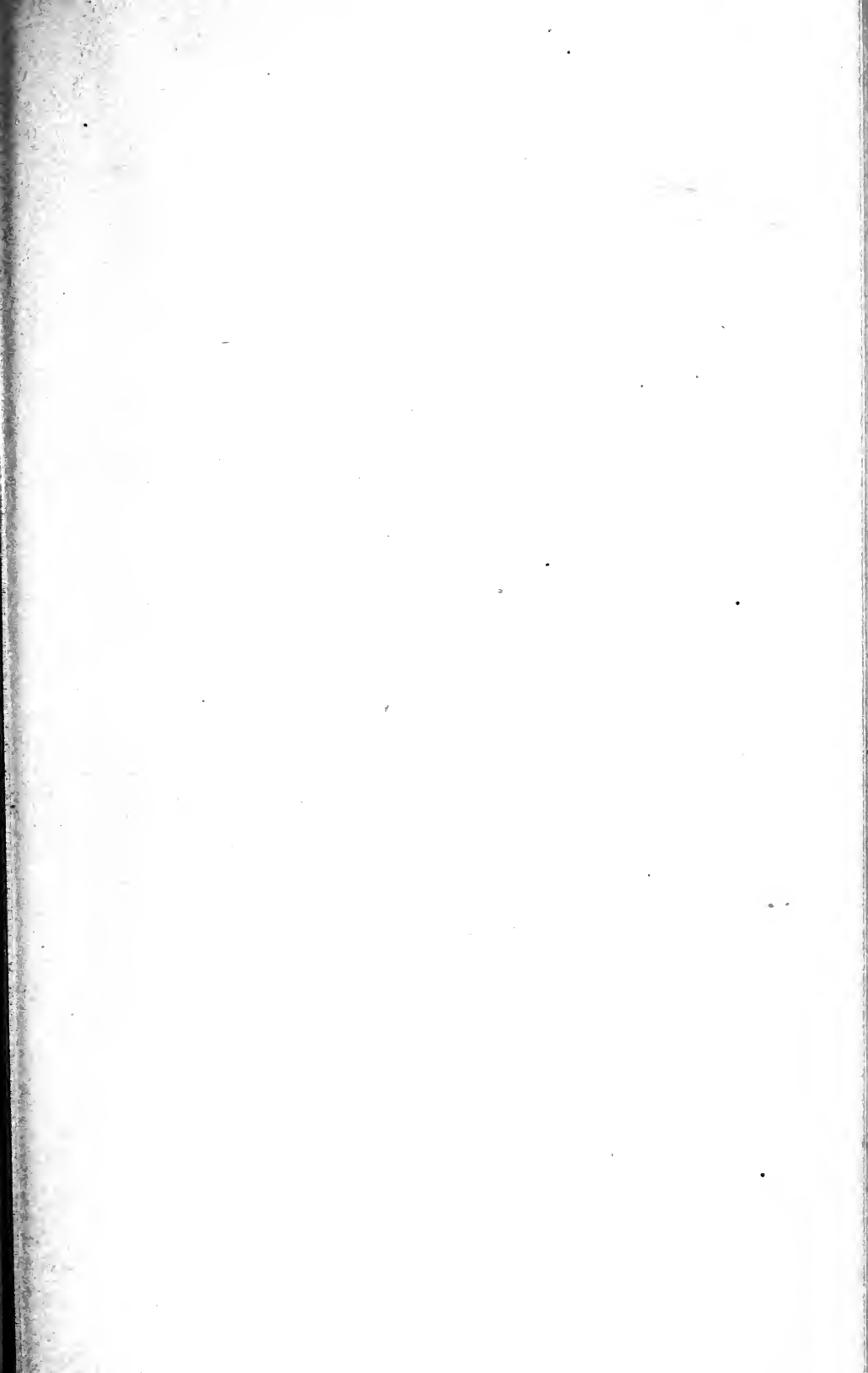
LACTOSE. (Milk Sugar.)

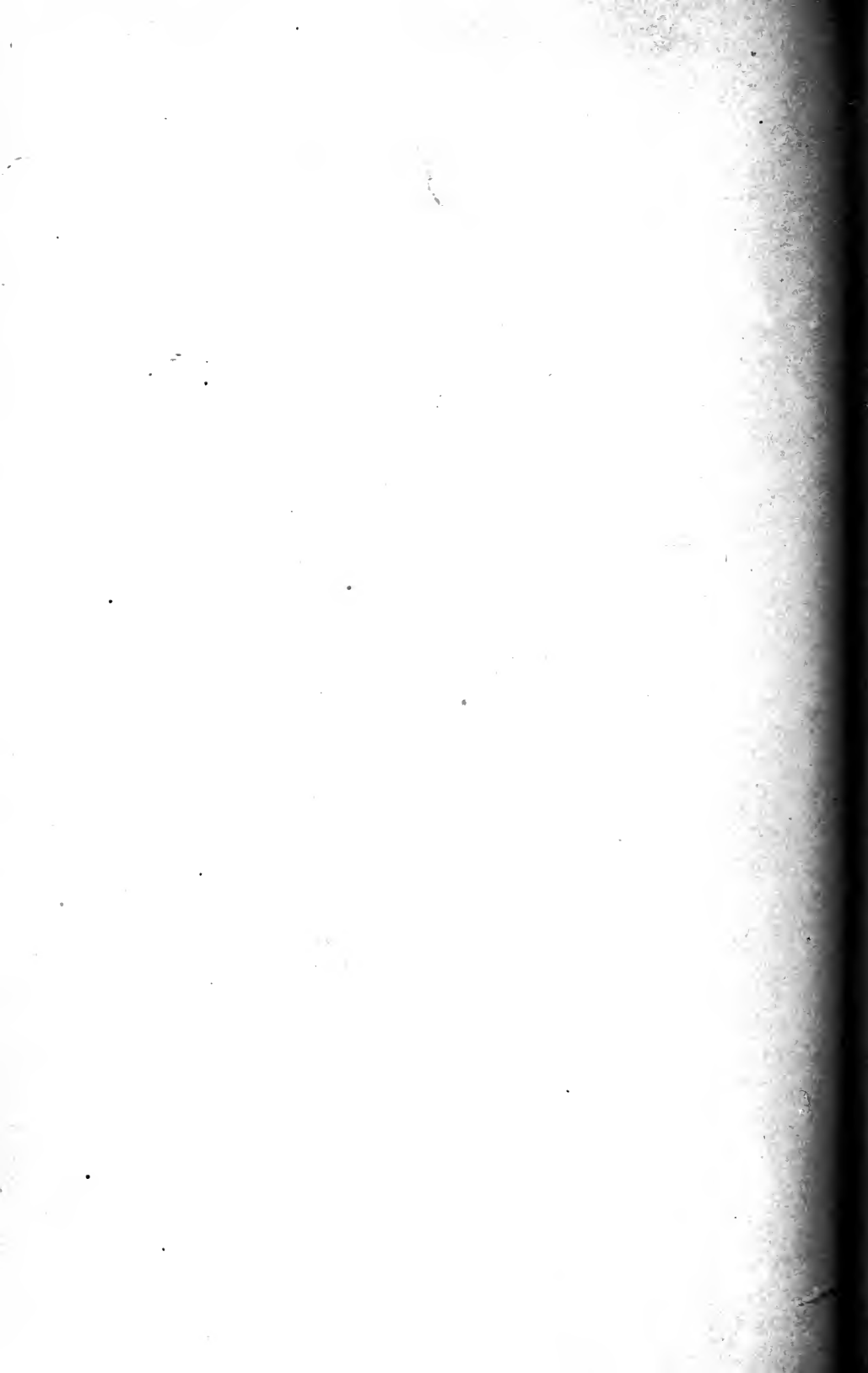
A white crystalline solid, less soluble in water than cane sugar or dextrose, insoluble in alcohol or ether. It possesses only a faint sweet taste.

Lactose responds to most of the tests for dextrose; it reduces Fehling's solution, though less strongly than dextrose, and answers to Trommer's test. It differs from dextrose in not directly undergoing alcoholic fermentation with yeast (commercial samples often ferment rapidly), and by giving negative results with Barfoed's test. In the phenylhydrazin test the crystals obtained are larger than with dextrose. By the lactic acid micro-organism, as in the ordinary souring of milk, lactose is converted first into lactic acid and then into butyric acid, but by certain other ferments, and by boiling with acids, it is changed into galactose which may then undergo ordinary alcoholic fermentation. The freedom of lactose from cane sugar may be tested by sprinkling it on strong sulphuric acid ; after one-half hour there should be no brown coloration. Lactose may be separated from milk by acidulating with dilute acetic acid, filtering off the coagulated caseinogen and evaporating the filtrate.

MALTOSE.

A white, crystalline substance, needle-shaped crystals, soluble in both water and alcohol, produced by the action of diastatic ferments on starch. Like lactose it responds to nearly all of the





glucose tests. Its reducing power with Fehling's Solution is one-third less than that of glucose, while its dextro-rotation of polarized light is more than twice as great. It readily undergoes alcoholic fermentation, and by prolonged boiling with water, or more easily by boiling with dilute acids, it is converted into dextrose.

Maltose resembles lactose but may be differentiated by means of the fermentation test. It differs from glucose, in giving a negative result when boiled with Barfoed's reagent.

CELLULOSE.

Prepared by reducing vegetable tissues to a pulp and washing out the starches, gums, salts, etc., present.

Cotton-wool, which is nearly pure cellulose, is suitable for most of the tests.

1.—To some cotton in a test-tube add a little sodium hydroxide. Warm the mixture and let it stand. Note that the fibres swell slightly and become more or less gelatinous.

2.—To a second sample add strong sulphuric acid and warm gently. Note that the cotton turns brown or black, and goes partially or entirely into solution.

3.—Dissolve some pure cellulose in a solution of ammonio-cupric hydroxide. Then add hydrochloric acid carefully until the blue color of the solution is destroyed, and note that the cellulose is precipitated in a stringy mass.

4.—Cellulose is insoluble in water, alcohol, or ether.

5.—By treatment with mineral acids cellulose can be partially converted into dextrose.

Cellulose treated with a mixture of nitric and sulphuric acids yields tetra- and penta-nitrates (*pyroxylin*) which dissolve in a mixture of ether and alcohol to form *collodion*. Longer treatment with the acids yields a hexa-nitrate, *gun cotton*, $(C_6H_7O_2)_2(NO_3)_6$, insoluble in ether and alcohol. *Celluloid* is a solution of pyroxylin in camphor.

STARCH.

A white, inodorous, tasteless substance, insoluble in ether, alcohol, or cold water. Under the microscope it appears in uniform granules of characteristic appearance.

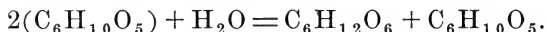
1.—Add a few grains of starch to a little sodium hydroxide in a test-tube. Note that the starch swells and forms a thick paste in the cold.

2.—Prepare some starch paste as follows: Add sufficient ground

starch to water in a test-tube to form a milky fluid. Pour this milky fluid into a beaker of *boiling* water. Note that the milky appearance disappears. Dilute some of the "paste" so formed, in another beaker with water. When cool, add a few drops of iodine solution. A blue color is produced. Divide this blue solution into three parts. (a) Heat one part carefully until the color disappears. Upon cooling, the color will again develop. If carefully performed this may be repeated several times. (b) To the second part, add a few drops of sodium hydroxide. The blue color is destroyed, but may be reproduced by the addition of dilute hydrochloric acid. (c) To the third part, add mercuric chloride. The blue color is destroyed.

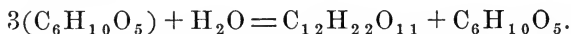
3.—Starch is insoluble in cold water, or in alcohol. When heated with water it is partially dissolved, the soluble portion being known as *granulose*, the insoluble portion, as *starch-cellulose*. To some of the clear starch solution obtained in (2) add alcohol. The granulose is precipitated.

4.—To some of the solution obtained in (2) add dilute hydrochloric acid and heat to boiling. Test a small portion of the solution in another test-tube, with iodine. If the boiling has been sufficient no color will appear, showing the conversion of the starch into dextrose and dextrin.



The dextrin first produced gives a red or brown coloration with the iodine.

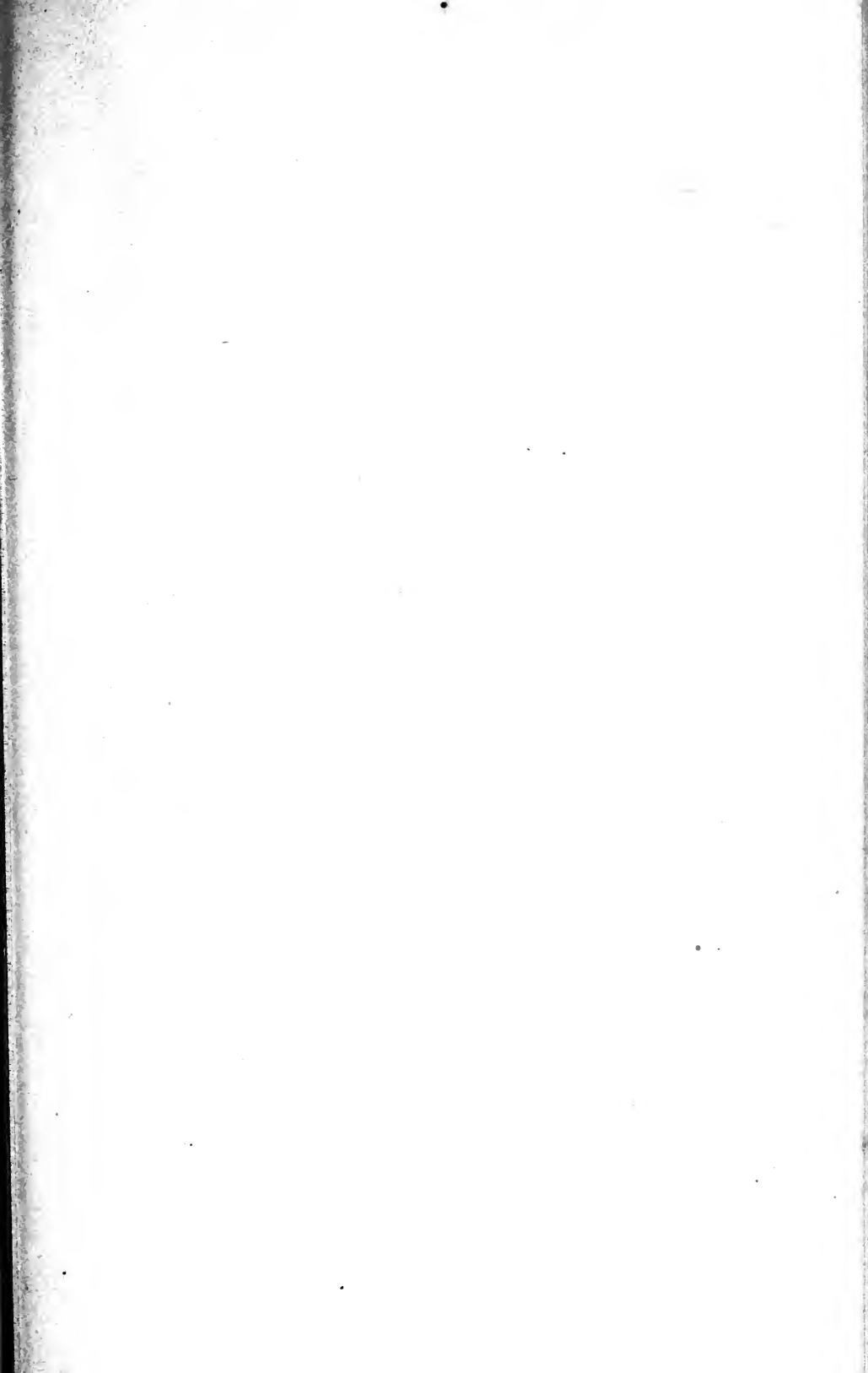
5.—By the action of diastatic ferments starch is converted into maltose and dextrin.

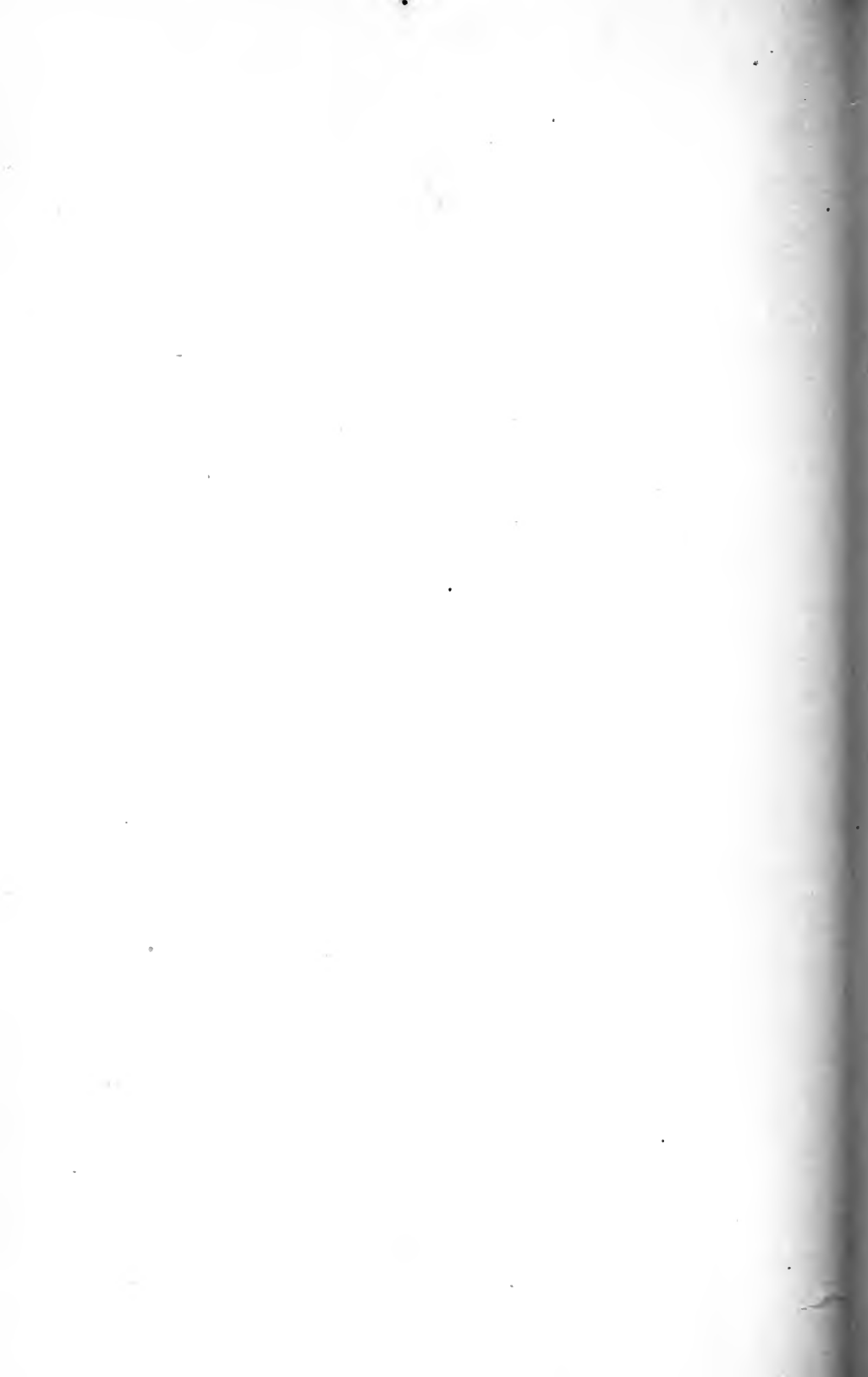


Mix a little of the diluted starch paste, prepared in 2, with saliva, and warm to about the temperature of the body. At intervals test a drop of the mixture with a drop of iodine solution on a porcelain plate. The blue color first obtained, indicating starch, will gradually give place to a brownish-red color due to erythro-dextrin. No color with the iodine shows conversion of the starch into achroo-dextrin. The presence of maltose may be proved by Fehling's test, q. v., both starch and dextrin being non-reducing.

DEXTRIN.

An amorphous substance, readily soluble in water, insoluble in





alcohol and in ether, produced by hydrolysis of starch and other amyloses. There are two varieties, *erythro-dextrin* which gives the iodine test below, and *achroo-dextrin* which does not give the iodine test. *Pure* dextrin is non-reducing, and does not undergo fermentation with yeast.

1.—Drop some of the aqueous solution into alcohol; a white precipitate is formed.

2.—A drop of iodine solution added to a solution of dextrin gives a reddish-brown coloration which disappears when the solution is heated, but reappears on cooling.

3.—Basic lead acetate gives no precipitate. (Unlike glycogen.)

4.—Boiling with dilute hydrochloric acid converts dextrin into dextrose.

GLYCOGEN.

A white or yellowish-white tasteless amorphous powder, insoluble in alcohol or ether, imperfectly soluble in boiling water. It is present in the tissues of the body, abundantly in embryonic tissue.

1.—With iodine, glycogen gives a deep red color when in solution, a brown color when in form of powder. On heating the solution the color disappears, but reappears on cooling.

2.—With sodium hydroxide and one or two drops of copper sulphate a blue coloration is obtained, but there is no precipitate on boiling. (See Trommer's Test, under Dextrose.)

3.—Basic lead acetate precipitates glycogen from its aqueous solution. (Unlike dextrin.)

4.—Boiling with dilute hydrochloric acid converts glycogen into dextrose.

THE PROTEIDS.

THE proteids occur in both the vegetable and animal kingdoms, most abundantly in the latter. They all contain carbon, hydrogen, oxygen and nitrogen; most of them contain sulphur, and phosphorus is present in a few. Various formulæ have been calculated for the simpler proteids, but little, however, is known regarding their true constitution. They vary in composition as follows (Hoppe-Seyler):

	C	H	N	S	O
From	51.5	6.9	15.2	0.3	20.9
To	54.5	7.3	17.0	2.0	23.5

On decomposition the proteids yield ammonium compounds, amines, fatty acids amido-acids, aromatic compounds, etc.

Classification :

A. SIMPLE PROTEIN SUBSTANCES.

I. FUNDAMENTAL. *Albumins*. 1. Egg-Albumin. 2. Serum-Albumin. 3. Cell-Albumin. 4. Muscle-Albumin. 5. Lact-Albumin.

Globulins. 1. Serum-Globulin. 2. Cell-Globulin.
3. Fibrinogen. 4. Myosinogen.

II. DERIVED. 1. *By action of acids or alkalies*, Acid-Albumin and Alkali-Albumin. 2. *By ferments*, Fibrin, Myosin. 3. *By ferments plus acids or alkalies*, Proteoses (Albumoses), Peptones. 4. *By heat*, Coagulated Albumins and Coagulated Globulins.

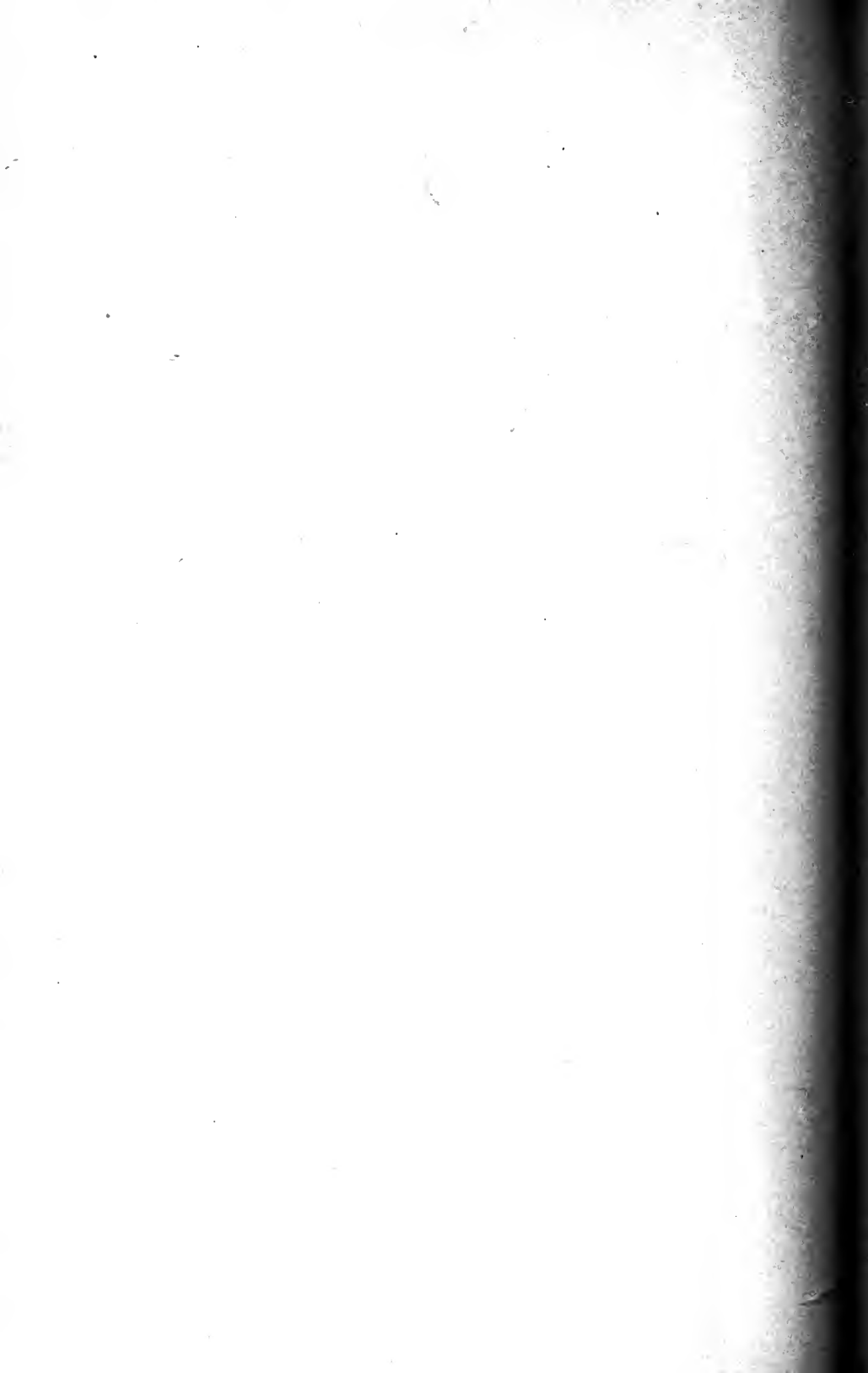
B. COMPLEX PROTEIN SUBSTANCES. (The "Proteids" of German authors.)

Mucin; Nucleo-Albumins, Caseinogen, Vitellin, and Thrombin; Hæmoglobin.

C. ALBUMINOID OR GELATINOID SUBSTANCES.

Collagen, Ossein and Gelatin; Chondrigen and Chondrin; Elastin; Eleidin and Keratin; Lardacein, etc.





TESTS FOR THE PROTEIDS.

All proteids are insoluble in alcohol. Some are soluble in water, others are not. Many not soluble in water are soluble in dilute saline solutions. Some are soluble in concentrated saline solutions, others are insoluble. All are soluble when heated with strong acids, and all are soluble, after change, in the gastric and pancreatic juices. The classification and subdivision of the proteids depend upon their behavior with the above reagents.

"*The Protein Reactions*" (Applying to nearly all protein bodies).

1.—*Xantho-proteic Reaction*.—To a little of the solution in a test-tube, add a few drops of conc. nitric acid and heat to boiling. A yellow color is produced. Cool, and render the solution alkaline with sodium hydroxide. An orange-yellow color is obtained.

2.—*Millon's Reaction*.—To the solution add a few drops of Millon's Reagent (See Appendix) and boil. The white precipitate first formed turns red on heating. The presence of sodium chloride interferes with this reaction.

3.—*Biuret Reaction*. (Piotrowski's.)—Render the solution alkaline with sodium hydroxide and add one or two drops of dilute copper sulphate; a violet coloration is obtained. With peptones, however, the color obtained is rose-red.

REMOVAL OF PROTEIDS FROM SOLUTIONS.

It is frequently necessary to remove the proteids from a solution preparatory to tests for other substances. In urine analysis, for instance, the albumin must be removed before testing for sugar, or for urea. This removal may be accomplished, in most cases, by heating to boiling the slightly acid solution. Albumins and Globulins are coagulated and may be filtered off. If the solution is not already acid, render so by addition of acetic acid. The same result may be obtained by the addition of an excess of absolute alcohol to the slightly acid solution, all proteids being thereby precipitated. A third method, of wide application, is the following: Add to the solution a few drops of acetic acid (sufficient to acidulate it), then saturate with crystals of ammonium sulphate. Boil for several minutes and filter. Saturation with ammonium sulphate precipitates all proteids except peptones.

ALBUMINS.

Albumins are soluble in water, in dilute saline solutions, and in saturated solutions of sodium chloride, and magnesium sulphate. They are coagulated by heat, egg-albumin at about 73° C., and are precipitated by saturation with ammonium sulphate.

1.—Mercuric chloride precipitates white albuminate of mercury.

2.—Copper sulphate precipitates blue albuminate of copper.

3.—Add to the solution a few drops of acetic acid and then a little potassium ferrocyanide. A precipitate is formed.

4.—*Picric Acid Test*.—Add to the solution a few drops of picric acid; a precipitate is formed.

5.—*Tannic Acid Test*.—Add to the solution a few drops of a solution of tannin. A precipitate is formed.

6.—*Nitric Acid* forms a white precipitate if not added in excess.

7.—*Nitric Acid Contact Test*.—Place about one inch of strong nitric acid in a test-tube, and float over it carefully, so as to avoid admixture, some of the solution to be tested. In the presence of albumin, a white cloudy ring, or zone, will form at the contact of the two liquids.

8.—*Acidulated Brine Test*.—Place the acidulated brine (see Appendix) in a test-tube, and float over it the solution to be tested. A white precipitate is formed at the juncture of the two liquids.

9.—*Tanret's Test*.—Place the Tanret's Solution (see Appendix) in a test-tube, and float over it the solution to be tested. A white precipitate is formed at the juncture of the two liquids.

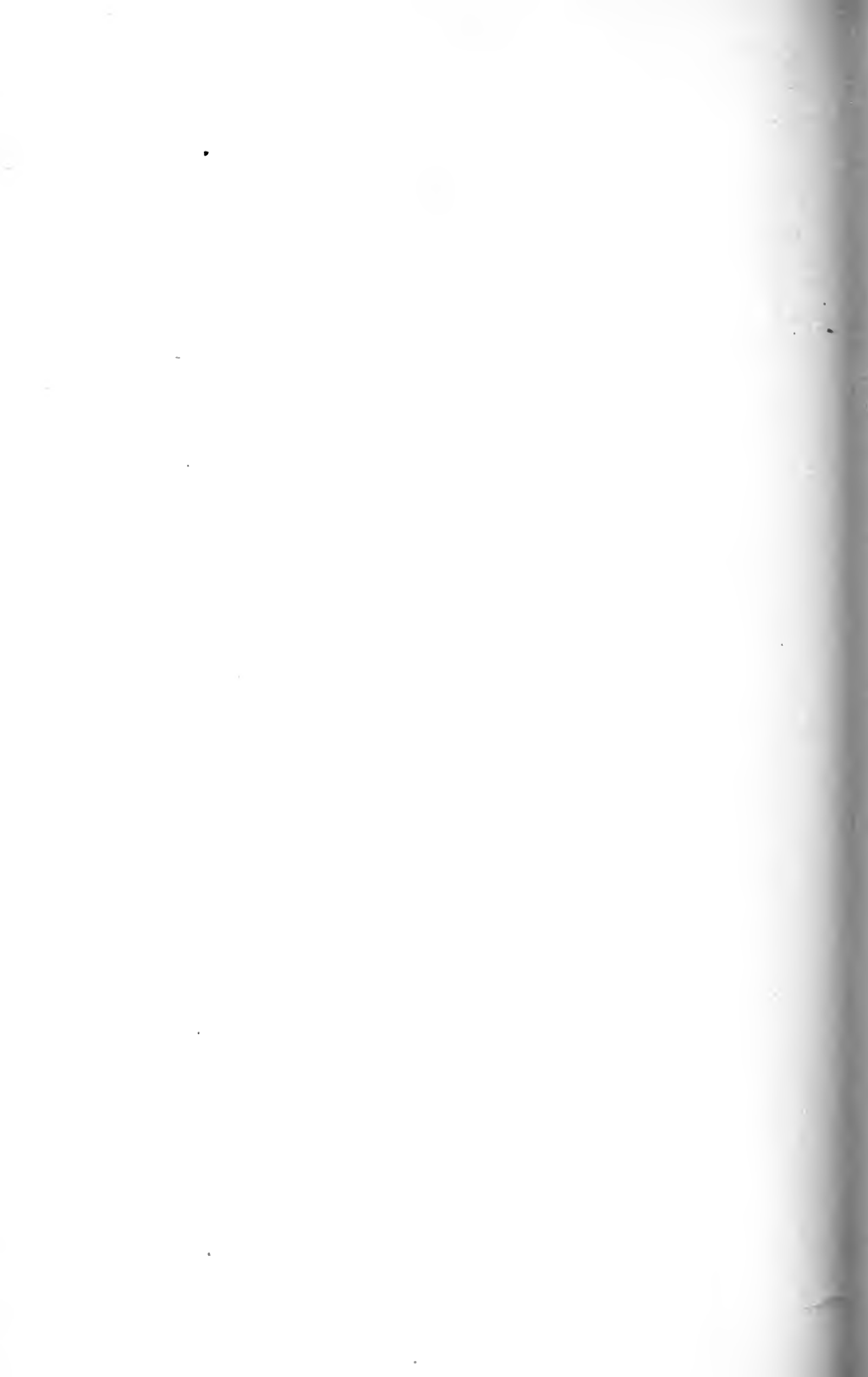
10.—*Trichloroacetic Acid Test*.—Add some of the crystals to the solution to be tested, and allow them to dissolve without agitation at the bottom of the tube. A white precipitate is formed.

11.—*Heat Test*.—Heat some of the aqueous solution of albumin just to boiling. The albumin is coagulated, forming a white precipitate. The solution should be slightly acid. The temperature at which the coagulation takes place averages between 60° C. and 75° C.

12.—Burn a small fragment of solid albumin on a piece of platinum foil. Note the characteristic odor of burnt horn.

Egg- and Serum-Albumin may be readily distinguished by the following tests :

10
A



Egg-Albumin.

Serum-Albumin.

- | | |
|---|--|
| 1.—Rapidly precipitated by alcohol. | 1.—Slowly precipitated by alcohol. |
| 2.—Precipitated by ether. | 2.—Not precipitated by ether. |
| 3.—Readily precipitated by HCl, the precipitate not dissolving in excess. | 3.—Not readily precipitated by HCl, the precipitate dissolving easily in excess. |

For the detection of Albumin in the Urine, see under Urine Analysis.

TESTS FOR SULPHUR IN ALBUMIN.

1.—Heat a solution of lead acetate in a test-tube and add sodium hydroxide until the white precipitate of lead hydroxide, first formed, *is just* redissolved. Boil the clear liquid, and while boiling add a little albumin solution. The mixture turns brownish-black from the formation of lead sulphide.

2.—Heat a little of the solid albumin in a tube, and hold in the mouth of the tube a piece of paper moistened with lead acetate. The paper is blackened by the fumes evolved.

3.—Boil some albumin solution with a few grains of bismuth subnitrate and an excess of sodium hydroxide. A brownish-black precipitate of sulphide of bismuth is formed.

GLOBULINS.

The globulins resemble the albumins in being soluble in dilute saline solutions, in being coagulated by heat, and in being precipitated by ammonium sulphate. In the latter case, however, half saturation (add equal volume of saturated ammonium sulphate solution) suffices to precipitate globulins, while for the precipitation of albumins full saturation with crystals of ammonium sulphate is required. Unlike the albumins, they are insoluble in pure water and insoluble in concentrated solutions of sodium chloride, or of magnesium sulphate.

Serum-Globulin, also known as fibrinoplastin and paraglobulin, is the principal globulin of the blood. *Fibrinogen* is that substance which, under the influence of a ferment, gives rise to the fibrin of clotted blood.

ACID- AND ALKALI-ALBUMINS.

Acid- and alkali-albumins, the so-called albuminates, are derived from albumins and globulins by the action of weak acids and

alkalies. They are soluble in acids and alkalies, and in dilute saline solutions, but are precipitated by saturation with neutral salts. They are not coagulated by heat.

1.—To the albuminous fluid add a considerable amount of acetic acid. An *acid-albumin* is formed. Boil, and note that there is no coagulation.

(a) Apply the xantho-proteic reaction to part of the solution obtained in 1.

(b) Add carefully, to another part of the same solution, dilute sodium hydroxide, and note that when the acid is just neutralized the albumin will be precipitated.

2.—To the albuminous fluid add a few drops of sodium hydroxide and warm the mixture. An *alkali-albumin* is formed. Boil the solution and note that there is no coagulation.

(a) Apply the biuret test to part of the solution obtained in 2.

(b) Add carefully, to another part of the same solution, acetic acid, and note that when the sodium hydroxide is just neutralized the albumin will be precipitated.

PROTEOSES AND PEPTONES.

The Proteoses are intermediate products in the digestion of proteids. They are not coagulated by heat. They are precipitated, but not coagulated, by alcohol. With nitric acid a precipitate is obtained which disappears on heating and reappears on cooling. With the biuret test proteoses behave much like peptones.

The Peptones are final products in the digestion of proteids. They are easily soluble in water and are not precipitated by heat, by nitric acid, or by ammonium sulphate.

Test a solution of a peptone as follows:

1.—Apply the Xantho-Proteic test. The characteristic coloration is obtained. *14 mols + heat yellow*

2.—Apply the Biuret test, taking care to use but a trace of copper sulphate. With a larger amount of copper salt the color obtained will be a purple-red, not unlike that given by other proteids.

3.—Mercuric chloride precipitates a white peptonate.

4.—Picric acid precipitates a yellowish-white picrate of peptone.

5.—Nitric acid, acetic acid and potassium ferrocyanide, and copper sulphate, give no precipitates with peptones. Note, also, that tests 3 and 4 are not obtained with dilute solutions.

$\text{NaOH} + \text{CaSO}_4 = \text{Residue}$



COAGULATED PROTEIDS.

Proteids coagulated by heat are insoluble in water, in weak acids or alkalies. They are soluble, after long boiling, with strong mineral acids, and in the gastric and pancreatic juices. Coagulate some egg-albumin by heat and test the coagulum according to the Xantho-Proteic, the Millon's, and the Biuret tests, all of which should give positive results.

COMPLEX PROTEIN SUBSTANCES.

Under this classification are included a number of compound bodies, compounds of an albumin or globulin with a radical foreign to the protein nature. The principal recognized members of the class are as follows: *Mucin* and *Metalbumin*, compounds of albumin or globulin with a carbohydrate radical; *Nucleo-Albumins*, including *Caseinogen*, *Vitellin* and *Thrombin*, phosphorus-holding compounds of albumin or globulin with a nuclein radical; *Hæmoglobin*, a compound of a globulin with an iron-holding radical.

Caseinogen was formerly classed as an alkali-albumin, and Vitellin as a typical globulin.

THE ALBUMINOIDS OR GELATINOIDS.

As important members of this class we have, *Collagen*, from the white connective tissue; *Ossein*, a collagen from the bones; *Gelatin*, derived from collagen by boiling with water; *Chondrin*, similar to gelatin, derived from the *Chondrigen* of the cartilages; *Elastin*, *Eleidin*, *Keratin*, *Lardacein* or *Amyloid Substance*, etc.

GELATIN.

When dried and pulverized bones are digested with dilute hydrochloric acid, the mineral salts are dissolved and ossein left behind. This last heated with water is rapidly converted into the substance gelatin. Test the properties of gelatin as follows:

1.—Try the action of cold water. The gelatin swells without dissolving.

2.—Warm the mixture and it will be found that the gelatin dissolves. Divide this solution into two parts:

(a) Allow one part to cool in a test-tube, and note that on cooling the gelatin separates out, or "gelatinizes."

(b) Boil the remainder of the solution for several minutes, and then let it cool. Note that now it does not gelatinize.

3.—To the solution obtained in 2, b, or to a fresh solution of gelatin, apply the following tests:

(a) The Xantho-proteic test gives a lemon-yellow color.

(b) The Biuret test gives the usual violet color.

(c) Millon's test is negative in result with *pure* gelatin.

(d) Mercuric chloride and picric acid give precipitates from strong solutions.

(e) Nitric acid gives no precipitate.

In dilute solution gelatin resembles peptone. The following tests will serve to distinguish between the two:

<i>Peptones.</i>	<i>Gelatin.</i>
1. Feeble osmotic power.	1. No osmotic power.
2. Alcohol precipitates with difficulty.	2. Alcohol precipitates easily.
3. Saturation with ammonium sulphate causes no precipitate.	3. Saturation with ammonium sulphate causes a precipitate.
4. Solutions do not gelatinize.	4. Solutions gelatinize.

SEPARATION AND IDENTIFICATION OF THE CHIEF PROTEIN CLASSES.

I. *If the proteid be solid*, test its solubility. 1.—Soluble in pure water.

(a) Coagulated by heat, *Albumins*.

(b) Not coagulated by heat, *Peptones*.

2. Insoluble in pure water, soluble in one per cent. solution of sodium chloride, *Globulins*, *Vitellin* and *Crystallin*.

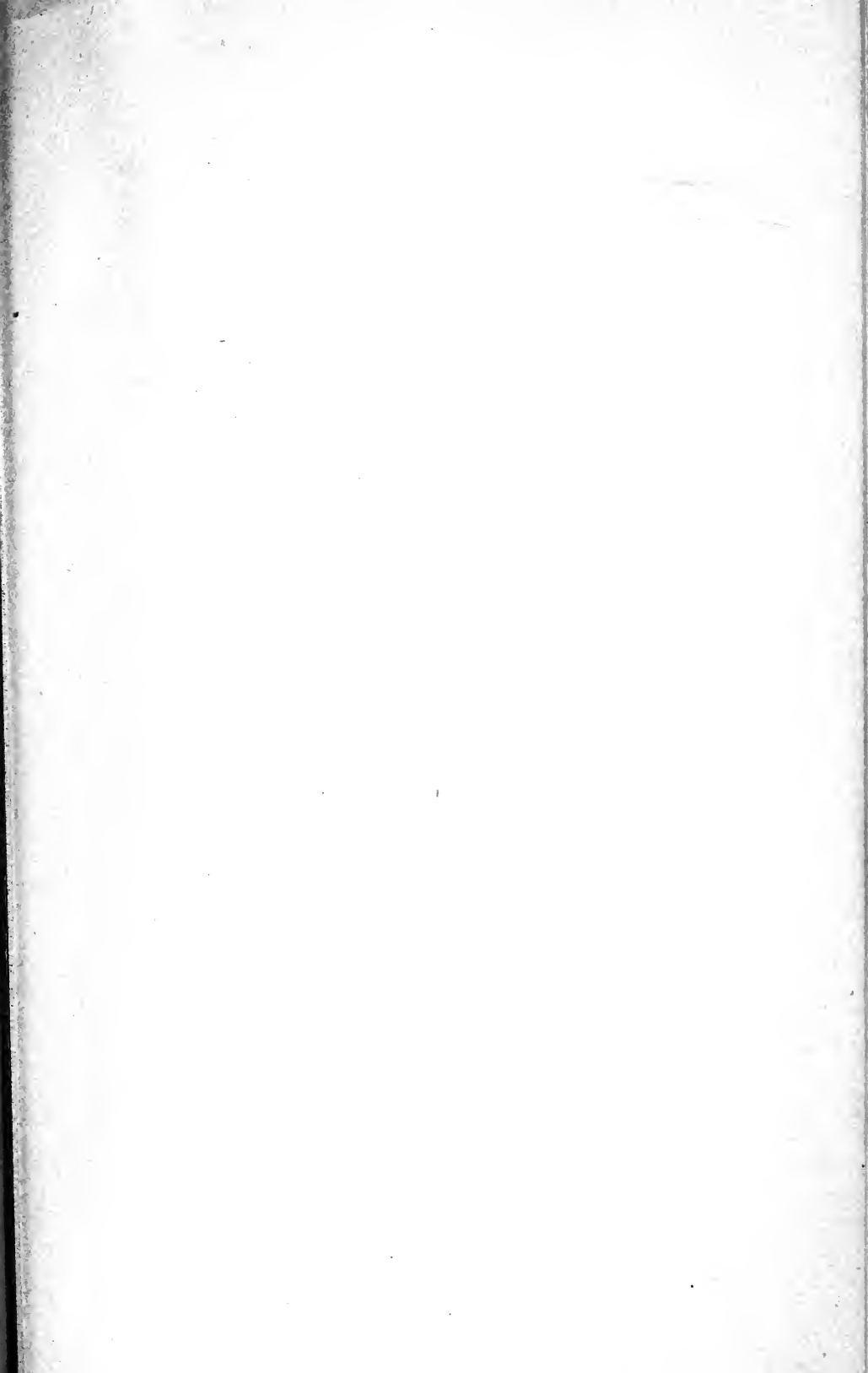
(a) Precipitated by saturation with sodium chloride, *Vitellin*, *Crystallin*.

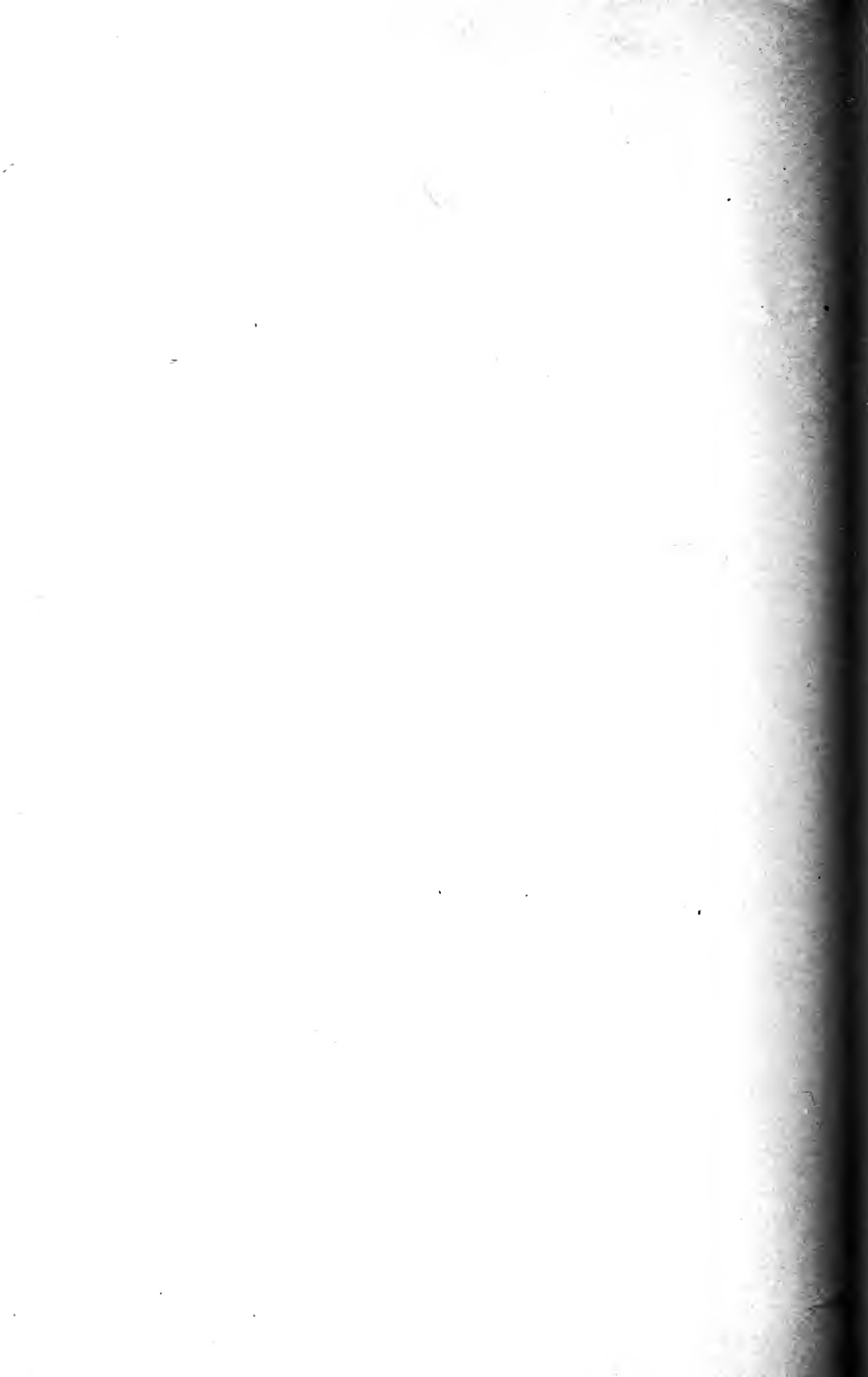
3. Insoluble in pure water or dilute sodium chloride, but soluble in acids and in the gastric juice.

(a) Soluble in dilute hydrochloric acid or in dilute alkalies, *Albuminates*.

(b) Insoluble in dilute acids and alkalies, but easily soluble when digested with gastric and pancreatic juice, *Coagulated Proteids*.

(c) Insoluble in water, sodium chloride, dilute acids, or gastric juice, soluble in the stronger alkalies and in strong hydrochloric acid. *Lardacein* (Amyloid Substance).





II. *If the proteid be in solution*, (1) Test a portion of the solution for proteids by the Xantho-proteic, Millon's and Biuret Tests.

2.—Test the reaction of the solution.

(a) If acid, apply tests for the *acid-albuminates*.

(b) If alkaline, test for the *alkali-albuminates*.

3.—Acidify, if necessary, and boil the solution. If there be a coagulation the proteid is either an *albumin*, or a *globulin*. Saturate some of the original solution with magnesium sulphate. A precipitate indicates *Globulin*; if no precipitate be formed, *Albumin* is present.

4.—If the proteid is not coagulated by heat, it is then probably either an albuminate, an albumose, or a peptone.

(a) *Albuminates* were tested for under II. 2, a, b.

(b) An *Albumose* would be recognized by the biuret reaction (similar to that given for peptones) and by the characteristic reaction with nitric acid. Albumose is precipitated by nitric acid in the cold, the precipitate dissolves on heating, and reappears when the liquid cools.

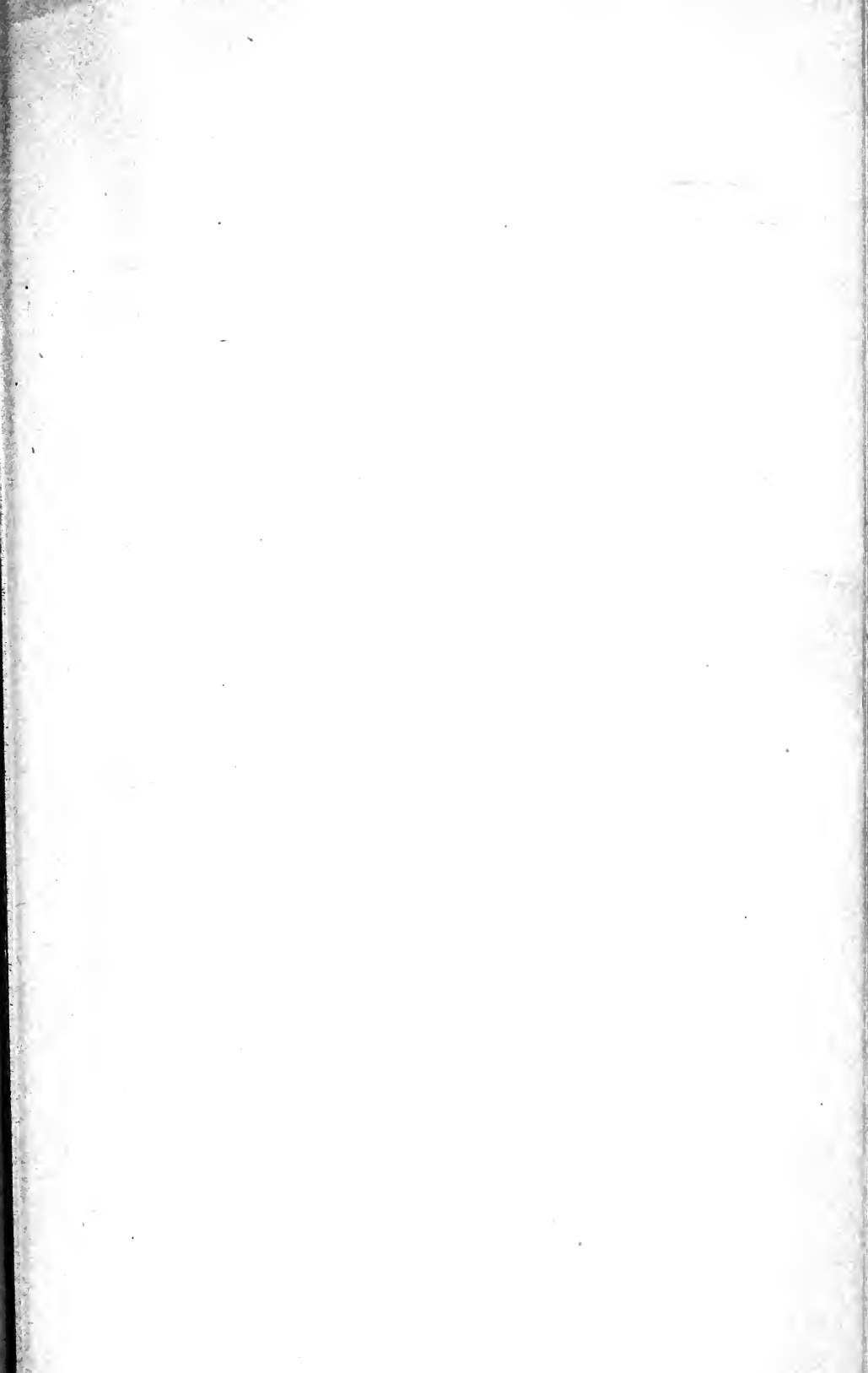
(c) *Peptones* may be recognized by the biuret reaction, by giving no precipitate with nitric acid, and no precipitate on saturation with ammonium sulphate.

THE FATS AND OILS.

The fat of adipose tissue is a mixture of the glycerides of palmitic, stearic and oleic acids, the trivalent glyceryl radical uniting with three univalent acid radicals, thus:—glycerol, $C_3H_5(OH)_3$; glyceryl, $(C_3H_5)^{III}$; palmitic acid, $HC_{16}H_{31}O_2$; palmitin, the fat $= C_3H_5(C_{16}H_{31}O_2)_3$. In the same way are formed the glycerides of stearic acid, $HC_{18}H_{35}O_2$, and oleic acid, $HC_{18}H_{33}O_2$. Butter fat contains, in addition, glycerides of butyric acid (C_4), caproic acid (C_6), caprylic acid (C_8), capric acid (C_{10}), lauric acid (C_{12}), and myristic acid (C_{14}), all acids of the series $HC_nH_{2n-1}O_2$. Olein is a liquid fat, palmitin and stearin are solid, stearin having the higher melting-point. The greater the proportion of olein present the more liquid will be the fat; the greater the proportion of stearin the more solid the fat. In the adult human body the fats are fluid during life, the body temperature being $37^\circ C$. and the mixture of fats present melting at about $26^\circ C$. The fats are soluble in hot alcohol, in ether and in chloroform; they are insoluble in water.

Test of Melting Point.—Heat some beef-fat in a dry dish, avoiding too high a temperature, and filter the melted fat obtained through dry filter paper. A one-fourth inch glass tube is closed at one end by fusion and the cooled, solid, fat introduced. The tube is then fastened to the bulb of a thermometer and suspended with it in a beaker of water, care being taken that no water enters the tube. The temperature of the water is gradually raised and the temperature at which the fat softens is noted. This will be between 40° and $50^\circ C$.

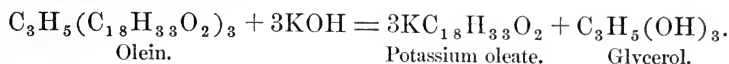
The fats vary in specific gravity from 0.91 to 0.97. They are insoluble in water and, generally, in cold alcohol, but are soluble in boiling alcohol, in chloroform, and, generally, in benzine and other petroleum products. Strongly heated they yield pungent, irritating fumes of acrolein. Decomposition of fat by putrefactive



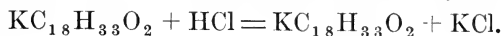


organisms results in the formation of propionic, acetic and formic acids—the fat becomes rancid.

Decomposed by ferments, by superheated steam, or by an alkali or metallic oxide, the fat yields glycerol and either the free fatty acid or a metallic salt of that acid known as a soap. The "saponification" of a fat with formation of a "soft" potash soap may be indicated as follows:



The ordinary soaps are soluble in water, but when added in excess the solution becomes turbid from a partial decomposition, free alkali and an insoluble acid salt being liberated. By addition of mineral acids the soap is decomposed and the fatty acid set free.



By addition of sodium chloride a "soft" potash soap may be transformed into a "hard" soda soap.



By the addition of other metallic salts the soda soap may be further transformed.

Saponification and Soap Tests.—Warm 10 c.c. of castor oil (or of olive oil) in a porcelain dish, and add slowly, with constant stirring, 10 c.c. of 10 per cent. sodium hydroxide solution. Continue the heating and stirring until the mass begins to thicken, then set aside to cool.

In making the test on so small a scale, the hard white soap obtained with castor oil is generally more satisfactory than the flaky "Castile Soap" (*Sapo U. S. P.*) obtained with olive oil.

Dissolve some of the soap in hot water and place in 6 test-tubes. 1.—Note the lather produced on shaking. 2.—Add CaCl_2 , and note that no lather is produced on shaking, but that an insoluble lime soap is precipitated. 3, 4 and 5.—Add, respectively, Fe_2Cl_6 , CuSO_4 , and $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$. Note the formation of iron, copper and lead soaps. 6.—Add a few drops of conc. hydrochloric acid and note the separation of the fatty acids. Warm, and the acids rise to the top of the liquid like oil.

Soft Soap, Sapo Mollis, U. S. P.—Heat 400 grammes of linseed oil to 60° C., and add slowly while stirring a solution of potassium hydroxide (90 grammes, in water, 450 c.c., and alcohol, 30 c.c.). Continue the heating and stirring until a portion of the soft mass

will dissolve in boiling water without separation of oily drops. The test may be satisfactorily made on the small scale, using proportionate amounts of oil and alkali.

Lead Plaster, Emplastrum Plumbi, U. S. P.—Mix 320 grammes of lead oxide (litharge) with 300 grammes of olive oil by trituration, and add the mixture to another 300 grammes of the oil in a capacious vessel. Then add 100 c.c. of boiling water, and boil, with constant stirring, until a portion dropped in cold water becomes pliable and tenacious. The water lost by evaporation must be replaced from time to time. When the whole is whitish and homogeneous, transfer to a vessel containing warm water and knead out the glycerin, renewing the water as necessary. The “plaster” consists essentially of lead oleate, $\text{Pb}(\text{C}_{18}\text{H}_{33}\text{O}_2)_2$. The test may be satisfactorily made on a smaller scale using proportionate amounts of lead oxide and of oil.

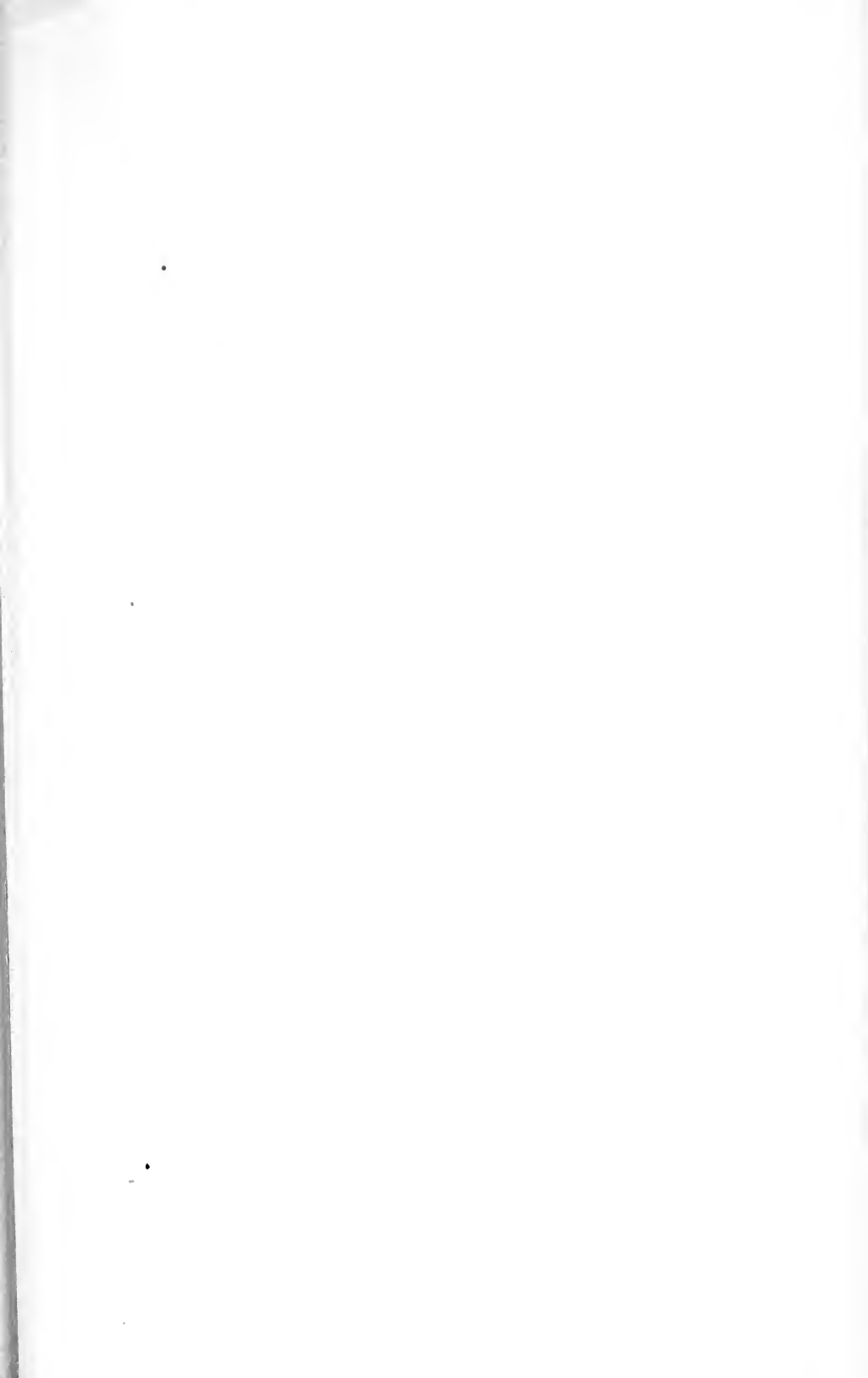
THE OILS differ from the solid fats in their greater proportion of olein and of other fats with low melting-points, and in their consequent fluidity at ordinary temperatures. As examples of the oils may be mentioned:

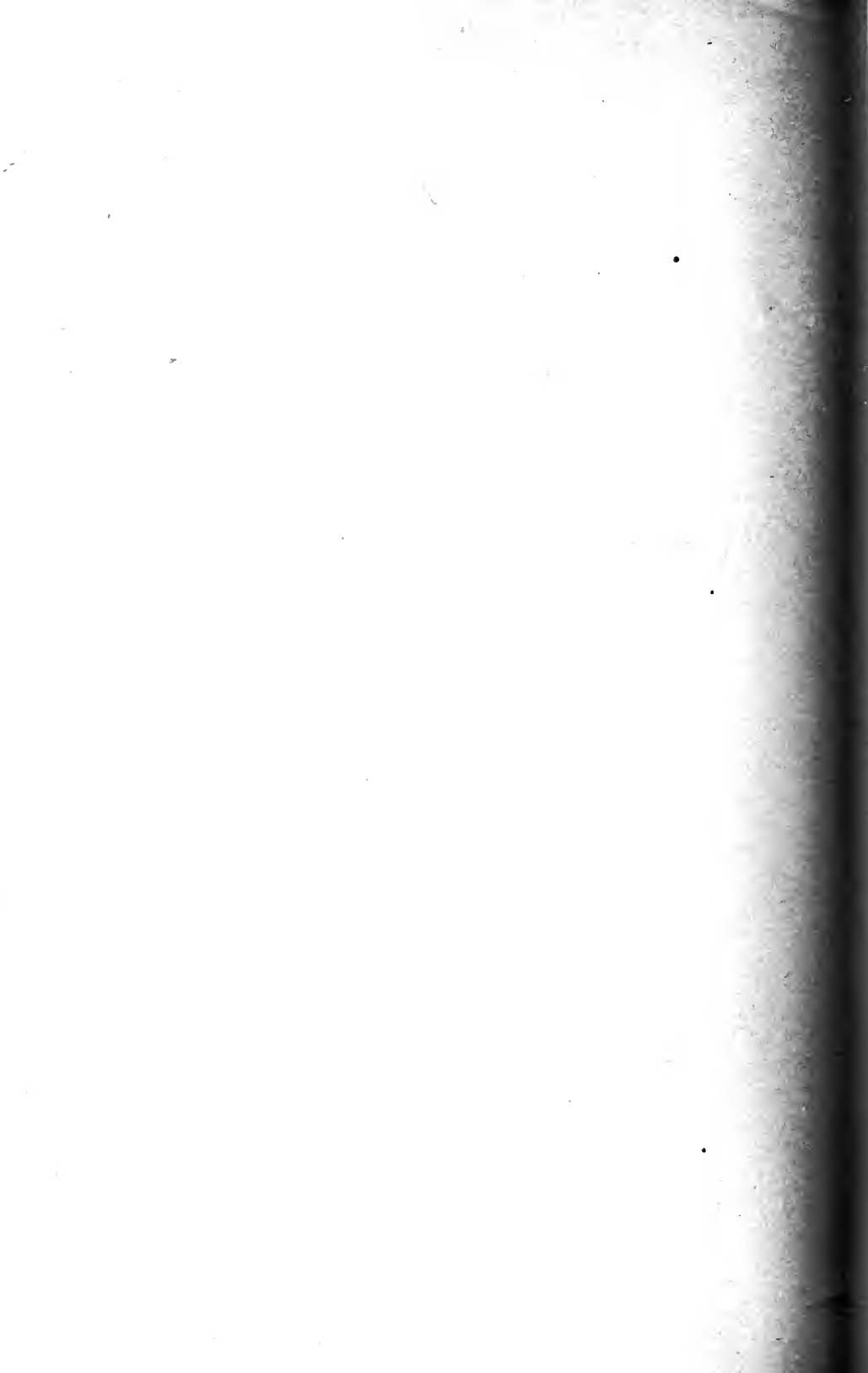
Castor Oil, a mixture of olein and ricinolein, $\text{C}_8\text{H}_5(\text{C}_{18}\text{H}_{33}\text{O}_2)_3$, with palmitin, etc. It is an almost colorless, viscid liquid, soluble in alcohol and in an equal volume, but not in an excess, of benzine. A drop of conc. sulphuric acid added to a few drops of the oil spread upon porcelain produces a brown coloration with a yellow margin.

Olive Oil consists chiefly of olein with palmitin, arachidin, cholesterol, and some albuminous matter. It is a pale greenish-yellow liquid with characteristic odor, sparingly soluble in alcohol, readily soluble in benzine, ether and chloroform. With sulphuric acid (see under castor oil) the coloration produced has a brownish center and an olive-green margin.

Cod Liver Oil is a mixture of olein with palmitin, myristin, and other more obscure compounds. It is a pale yellow, thin, oily liquid, easily soluble in benzine, ether, and chloroform, but nearly insoluble in alcohol. With sulphuric acid (see under castor oil) the coloration produced has a reddish-brown center and more or less of a purple margin.

LECITHIN, a complex fat containing phosphorus, is found in nerve tissue, in cell protoplasm, in the bile, blood, etc. On decomposition it yields glycerol, stearic acid, choline, and phosphoric acid.





FERMENTS AND FERMEN- TATION.

The ferments are divided into two classes, the Organized and the Unorganized.

The *Organized ferments* are living cells, the multiplication of which is accompanied by changes in the tissues upon which they feed. In this chemical metamorphosis complex compounds are resolved into simpler forms.

As examples of the more simple reactions of this class we have the conversion of glucose into alcohol and carbon dioxide by the yeast plant, the change of lactose into lactic acid by the bacterium *lactis*, the change of urea into ammonium carbonate by the micrococcus *ureæ*. More complex are the changes in the putrefaction of organic matter by such organisms as the bacterium *termo*, bacterium *subtile*, and the *proteus*. In many cases the products of the reaction are specific poisons, as is instanced by the bacilli of anthrax, of septicæmia, diphtheria, typhoid, etc., etc. *Ptomaines* are alkaloidal substances formed in putrefaction, while *Toxins* or *Toxalbumins* are of proteid nature, and like ptomaines only in being of bacterial origin. (*Leucomaines* are similar to ptomaines in composition, being alkaloidal in nature, but are products of normal metabolism.)

In the putrefaction of albumin we have an instance of the great complexity of certain of the decompositions. Among the products of the bacterial action here we find: peptones, ptomaines such as peptotoxin, neuridine, neurine, choline, cadaverine, putrescine, etc.; nitrogenous bases, such as leucin, tyrosin and amines; formic, acetic, propionic, butyric, valerianic, palmitic, lactic and succinic acids; indol, phenol, cresol, pyrocatechol, hydroquinol, hydro-paracumaric acid, etc., etc.; finally, hydrogen sulphide, ammonia, carbon dioxide, and water.

The *Unorganized ferments* or *Enzymes* are amorphous, proteid substances, originating in animal and vegetable cell action. They

are soluble in water, insoluble in alcohol, and may be extracted from their source by water, by salt solution, or, best, by glycerol. They may be classed as follows:

I. Amylolytic: ptyalin, amylopsin, diastase. Change amyloses into sugars. (Polysaccharids into disaccharids.)

II. Proteolytic: pepsin, trypsin, papain. Change albumins, etc., into peptones.

III. Steatolytic: steapsin. Decomposes fats into fatty acids and glycerol.

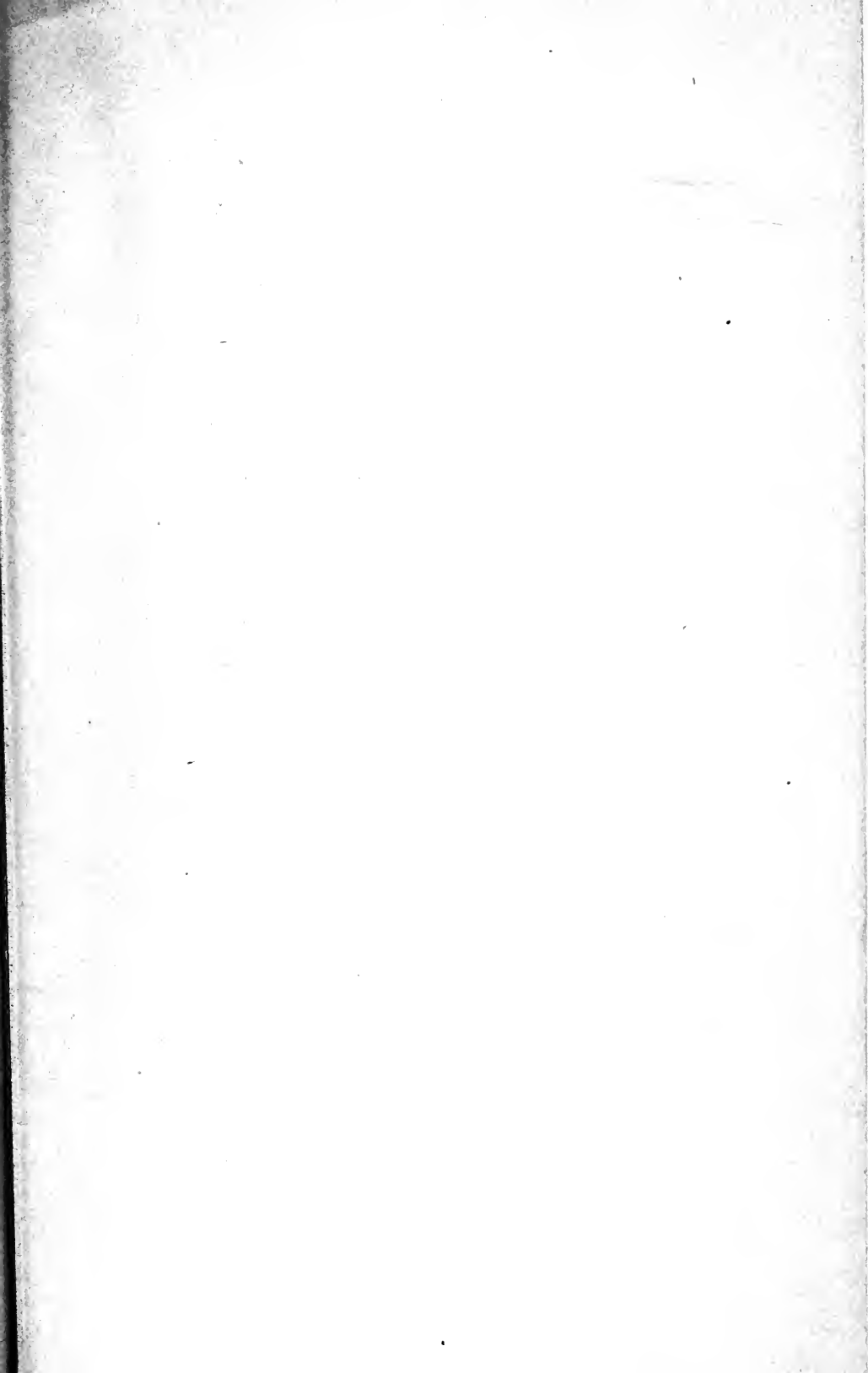
IV. Inverting Enzymes: invertin. Changes cane sugar, etc., into glucoses. (Disaccharids into monosaccharids.)

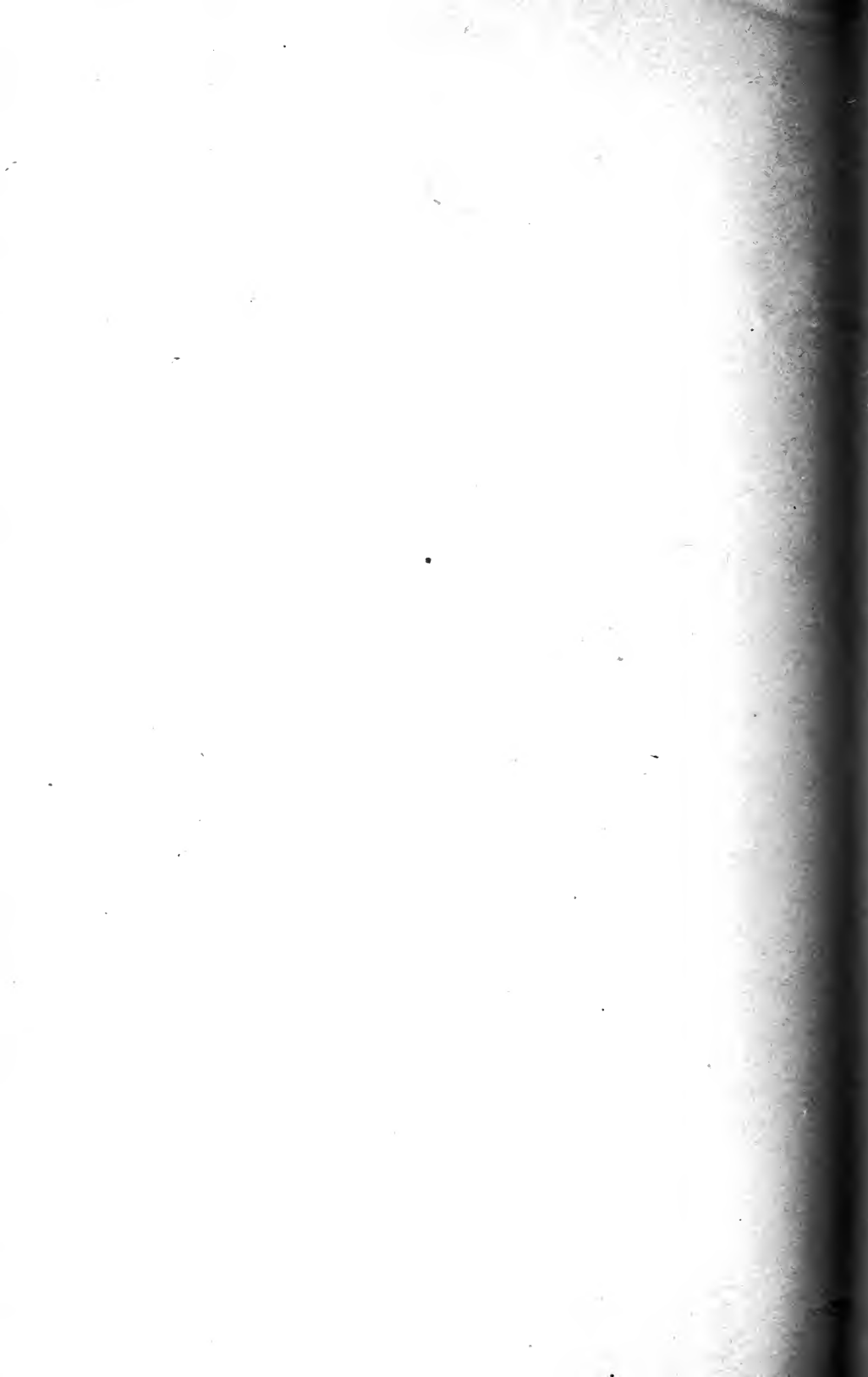
V. Coagulating Enzymes: chymosin, thrombin, myosin ferment. Coagulate proteid compounds.

VI. Glucoside-decomposing Enzymes: emulsin and myrosin.

It will be observed that many of the enzymes belong to the class of digestive ferments. These will be referred to in more detail in the discussion of the digestive fluids.

Controlling Influences in Fermentation.—The living ferments and the enzymes are both generally easily killed by a moist heat of 100° C., but when perfectly dry many will stand a temperature of from 100° C. to 160° C. They are rendered quiescent but are not killed by exposure to cold. A temperature of 35°–40° C. is generally the most favorable to both classes. Arsenious oxide, phenol, salicylic acid, chloroform and ether will kill many of the organized ferments, but generally have a less destructive action upon the enzymes. Most of the enzymes find their most favorable environment in a neutral medium, or in one that is faintly alkaline; pepsin, however, requires a neutral or acid medium.

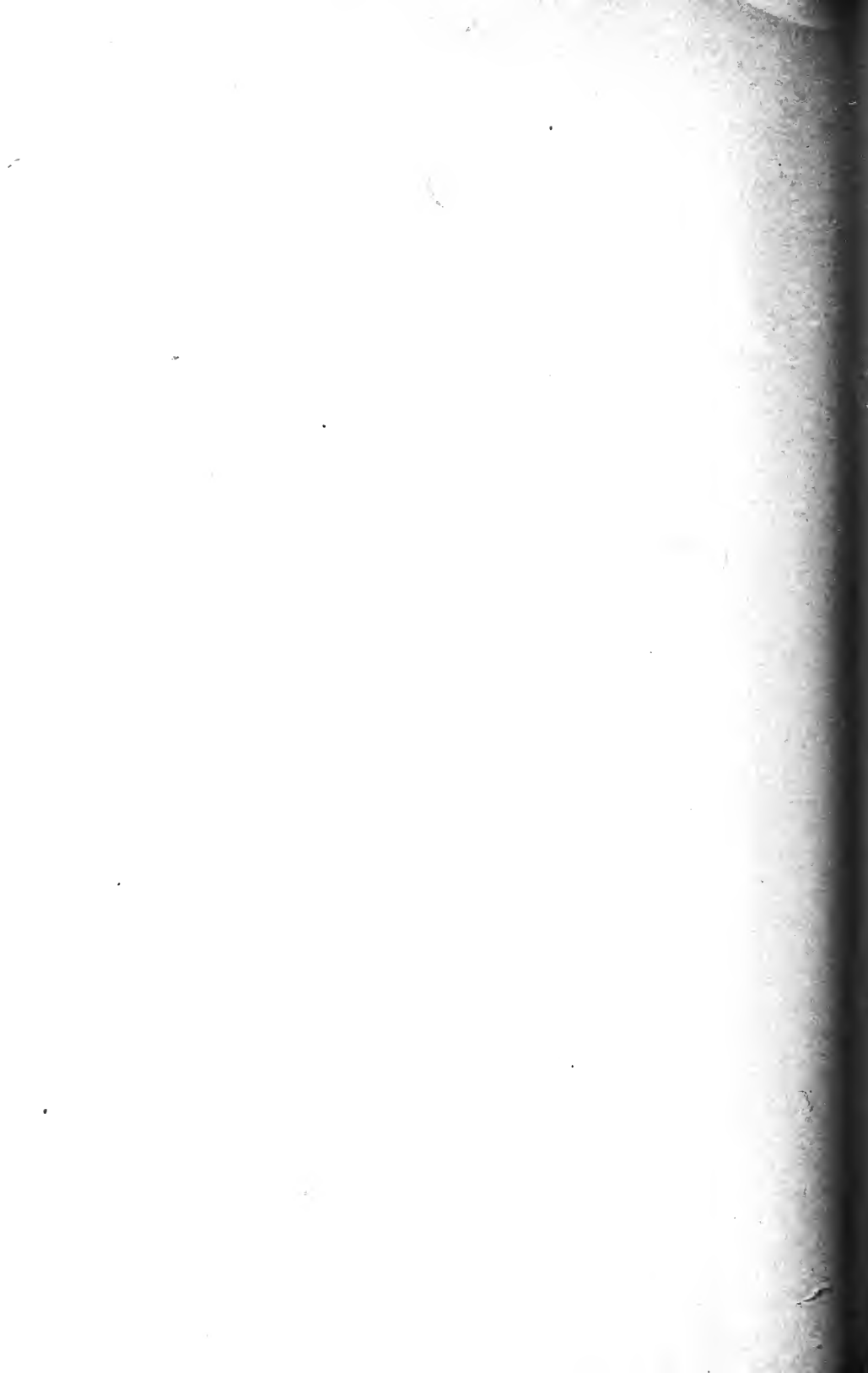




PART III.

CLINICAL.





THE BLOOD.

THE blood is an opaque, viscid, reddish fluid, with characteristic odor and a salty taste. The *Specific Gravity* averages about 1.060, but may vary from 1.045 to 1.075. The *Color*, due to the contained hæmoglobin, varies, with the degree of oxidation of this substance, from scarlet in arterial blood to bluish-red in venous blood. The depth of color naturally depends upon the amount of hæmoglobin present and therefore varies in certain diseased conditions, *e. g.*, being pale in chlorosis, anæmia, leucæmia, etc. Certain poisonous gases also affect the color, hydrogen sulphide producing a brownish-green tint, carbon monoxide a cherry-red, chlorine a greenish-yellow, and arsenetted hydrogen a brown tint. The *Reaction* is alkaline, the alkalinity being due principally to the disodium phosphate, and sodium hydrogen carbonate, contained. Glazed litmus paper may be used in testing the reaction.

Anatomical Composition :

Blood	{	Plasma	{	Serum	}	Clot, including some in- terstitial serum.
		Averages 60 p. c.		Fibrinogen		
	{	Corpuscles	{	Red Corpuscles		
		Average 40 p. c.		Leucocytes		
				Blood Platelets		

Chemical Composition :

	Blood. ¹ Man.	Blood. ¹ Woman.	Serum. ²	Red Corpuscles ³ (Moist).
Water,	77.90	79.10	90.79	68.80
Solids,	22.10	20.90	9.21	31.20
Albumin, }	7.60	7.60	4.52	2.63
Serum-globulin, }			3.10	
Hæmoglobin,	13.44	12.18	—	27.52
Fibrinogen,	0.22	0.22	—	—
Extractives and Fat,	0.16	0.16	0.71	0.24
Mineral Salts,	0.68	0.74	0.88	0.81

¹ Becquerel and Rodier. ² Hammarsten. ³ Calculated from analyses by G. Schmidt and Hoppe-Seyler.

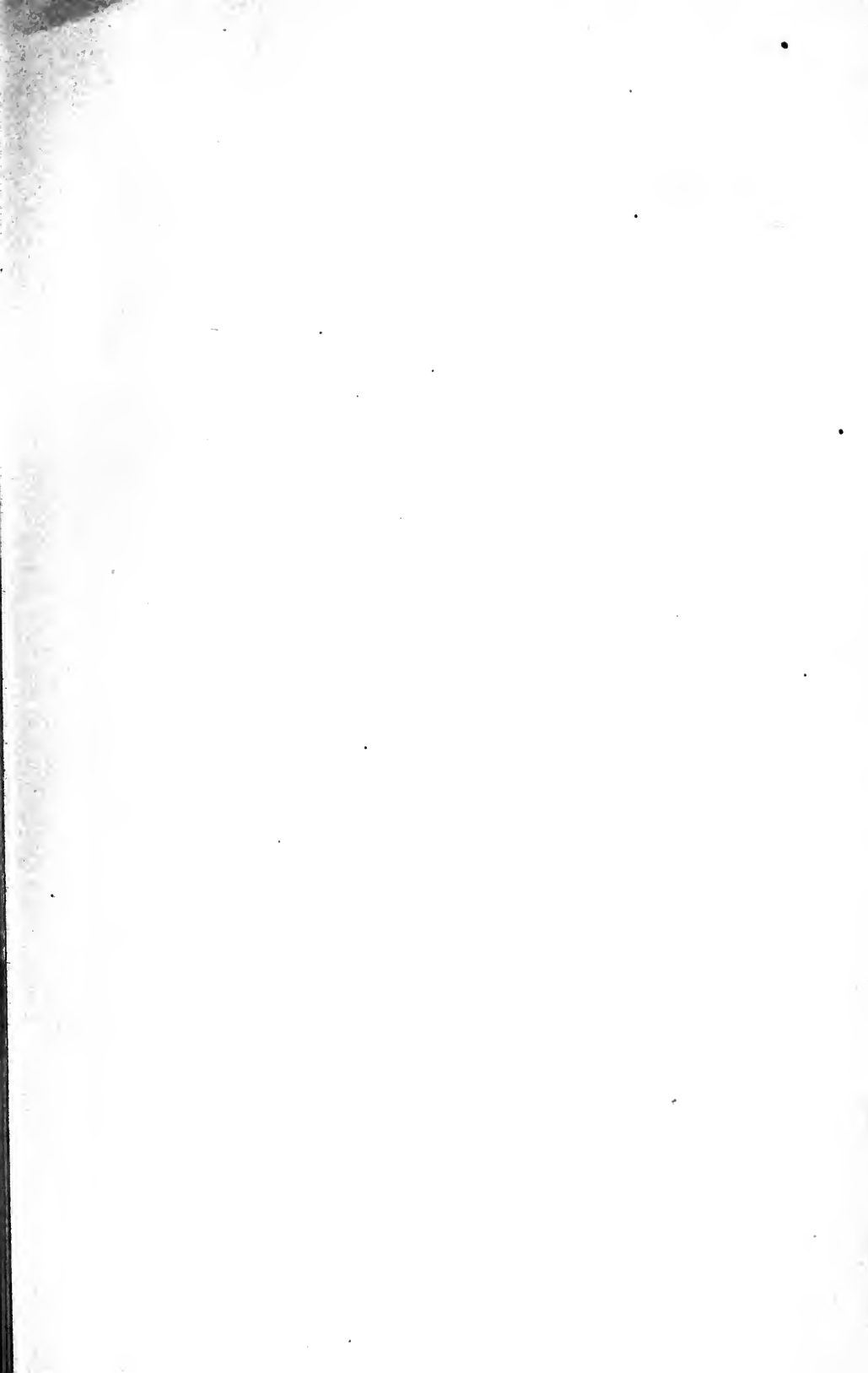
The gases in human blood, measured at 0° C. and 760 mm., are given as follows (Foster): Arterial blood; Oxygen, 20 p. c., Carbon dioxide, 39 p. c., Nitrogen, 1-2 p. c. Venous blood; Oxygen, 8-12 p. c., Carbon dioxide, 46 p. c., Nitrogen, 1-2 p. c.

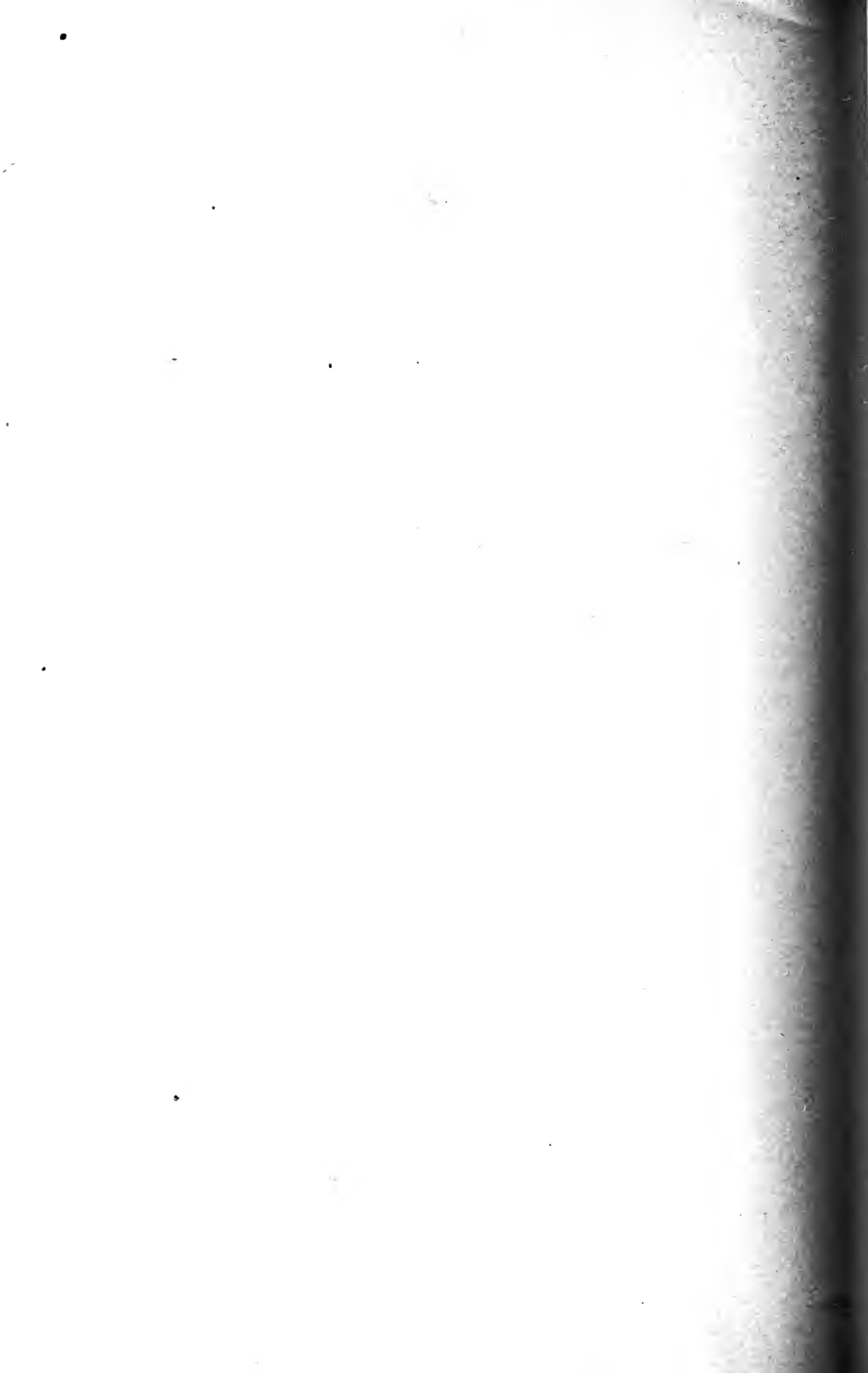
The Mineral Salts of blood consist of chlorides, carbonates, phosphates, and sulphates of sodium and potassium, with phosphates of calcium and magnesium. In the serum the salts of sodium are the more abundant, in the corpuscles, the salts of potassium. The iron from the hæmoglobin averages about 0.05 per cent. of the blood.

THE PLASMA. The plasma is a viscid yellowish liquid with strong alkaline reaction. Owing to a change in one of its constituents, Fibrinogen, it coagulates readily, separating into Fibrin and Serum, the change being effected by a special unorganized ferment, *thrombin*, a product of the disintegration of the leucocytes and blood platelets. The Fibrin so formed is an insoluble, grayish-white, stringy substance, elastic and retractile. The *coagulation is hastened* by raising the temperature to a little above that of the body, by contact with most foreign matter, by agitation, and by addition of a small amount of a neutral salt. The *coagulation is hindered* by a low temperature, by contact with a living vascular surface, with oils and oily surfaces, by addition of a considerable amount of a neutral salt, by small amounts of alkalies, by addition of acetic acid, by excess of carbon dioxide and by excess of water. Coagulation takes place only in the presence of calcium salts and may, therefore, be prevented by allowing the blood to flow into a solution of potassium oxalate of such strength that the resulting mixture will contain about one-tenth per cent. of the reagent. The calcium salts are precipitated as calcium oxalate.

THE SERUM differs from the plasma only in the absence of fibrinogen, and hence may be obtained, after coagulation, as an exudation from the clot, any remaining corpuscles being removed by means of the centrifuge. The chief *Proteids* of the serum are Serum-Albumin and Serum-Globulin, the latter being also known as Paraglobulin and as Fibrino-plastin. The two may be easily separated by saturation with magnesium sulphate; the albumin remaining in solution while the globulin is precipitated.

The principal "*Extractives*" of the serum are the neutral fats, most abundant after a meal of fatty food, and Cholesterol, an alcoholoid substance, $C_{27}H_{45}OH$, widely distributed in the body.





Lecithin, a complex phosphorus-holding body characteristic of nervous tissue, is present in the blood in small amount. Other extractives are Urea, Uric Acid, Creatine, Xanthine, Hypoxanthine, Hippuric Acid, and Carbohydrates. The *Mineral Salts* of the serum include sodium chloride, carbonate, sulphate, and phosphate, smaller percentages of the corresponding potassium salts, and phosphates of calcium and magnesium.

THE BLOOD CORPUSCLES (HÆMOCYTES). The *Leucocytes*, also known as the "white" or "colorless" corpuscles, are typical cells with nucleus and protoplasm. They average from 5–10,000 per cubic mm. of blood, and vary in size from 0.005 to 0.010 mm. in diameter. The protoplasm of the cell consists chiefly of cell-globulin and cell-albumin, but contains, also, glycogen, fat, lecithin, cholesterol, and some mineral matter. The nucleus is characterized by the presence of a phosphorus-holding body, nuclein. Various forms of leucocytes are recognized: Large cells with polymorphic nuclei, called polynuclear; small mononuclear forms; and transitional forms. The leucocytes are also classified according to the staining of the contained granules: Acidophiles or eosinophiles, staining with acid stains, *e. g.* eosin; basophiles, which stain with basic stains, *e. g.* methylene blue; and neutrophiles, which stain with neutral stains, *e. g.* combined methylene blue and eosin. The following methylene-eosin stain is useful in all cases: 60 parts of a concentrated water solution of methylene blue, 20 parts of a one-half per cent. solution of eosin in 70 per cent. alcohol, 40 parts of distilled water, and 12 drops of 20 per cent. potassium hydroxide.

The *Blood Platelets* measure from 0.002 to 0.004 mm. in diameter. Nothing definite is known as to their composition. They are more numerous than are the leucocytes.

The *Red Corpuscles* (Erythrocytes) measure from 0.007 to 0.008 mm. in diameter, in man, and number about 5,000,000 per cubic mm.

Nearly 90 per cent. of the dried red corpuscle consists of *Hæmoglobin*, an iron-holding proteid, $C_{600}H_{960}N_{154}FeS_3O_{179}$ (Preyer), crystalline but not diffusible. In arterial blood the hæmoglobin is loosely combined with an additional molecule of oxygen forming *Oxyhæmoglobin*, a substance soluble in water and alkaline liquids, insoluble in absolute alcohol, ether, chloroform and acids. The additional oxygen molecule may be easily separated by means

of reducing agents. *Methæmoglobin*, a similar substance formed during the drying of blood, and also by the addition of potassium ferricyanide, differs from the last in that the additional oxygen is closely combined. With carbon monoxide, hæmoglobin forms a cherry-red combination, known simply as *Carbonic-oxide-hæmoglobin*. Hæmoglobin consists of a brownish pigment, *Hæmatin*, $C_{34}H_{34}N_4FeO_5$ (Gautier), united with a globulin, the globin. The pigment may be demonstrated by adding NaOH to the blood. By heating blood in presence of glacial acetic acid and a little salt, the *Hydrochloride of Hæmatin*, formerly known as *Hæmin*, may be separated in dark, brownish, triclinic plates and prisms. *Hæmatoporphyrin*, $C_{34}H_{34}N_4O_5$ (Gautier), is artificially produced by the action of sulphuric acid on hæmatin. It is produced naturally within the body, and is sometimes present in the urine. *Hæmatoidin*, $C_{32}H_{36}N_4O_6$, formed in old extravasations, appears to be practically identical with bile pigment.

ABSORPTION SPECTRA OF BLOOD PIGMENTS.—In blood diluted with 250 parts of water *Oxyhæmoglobin* gives two absorption bands between D and E, that nearer D being the narrower and darker. *Hæmoglobin* gives one broad band extending from near E to a little beyond D. *Carbonic-oxide-hæmoglobin* gives a spectrum similar to that of oxyhæmoglobin, but the bands are narrower and slightly nearer the violet end. *Methæmoglobin* gives three bands, one in the red between C and D, the others in the position of the oxyhæmoglobin bands. *Alkaline Hæmatin*, made by dissolving hæmatin in strong alkali, or by adding strong alkali to a solution of oxyhæmoglobin, gives one ill-defined band extending from D toward C. *Hæmochromogen*, a substance formed by addition of ammonium sulphide to a solution of alkaline hæmatin, gives one band midway between D and E, and a second, fainter, band between E and b. This spectrum is one of the most useful for purposes of identification. The band between D and E is given in very dilute solutions. Acid solution of *Hæmatoporphyrin* gives a dark band midway between D and E, and a fainter, narrower, band to the left of D.

THE BLOOD IN DISEASE.

In *Leucocytosis*, physiological and pathological, the leucocytes are increased. In *Anæmia* the red corpuscles are decreased, and there is a proportionate decrease in hæmoglobin; the leucocytes



may be increased. In *Pernicious Anæmia* the red corpuscles are greatly decreased and are irregular in size and shape (poikilocytosis); the hæmoglobin is decreased, but not in proportion. Leucocytes are not materially increased and may be normal. In *Leucocythæmia* the leucocytes are greatly increased and the red corpuscles are slightly decreased. In the spleno-medullary form of the disease the increase is chiefly of the large mononuclear and polynuclear leucocytes. In the lymphatic form the increase is chiefly of the small mononuclear leucocytes. In *Chlorosis* the red corpuscles may be normal or slightly decreased; the hæmoglobin is greatly decreased.

In hæmoglobinæmia, the hæmoglobin passes from the corpuscles to the plasma, and may be present in the urine (hæmoglobinuria). In septicæmia, the hæmoglobin is reduced in amount, while there is an increase in the number of leucocytes and an increase in the amount of fat, urea, etc. In liver and biliary disorders, bile pigment, and in obstruction of the bile ducts, bile acids may appear in the blood. In acute yellow atrophy of the liver, there is a considerable amount of leucin and tyrosin in both blood and urine. In kidney diseases there is often a decrease in the percentage of albumin, while urea, fats, and fibrin are all increased. In diabetes mellitus there is an increased amount of dextrose, and ethyldiacetic acid may be present.

EXAMINATION OF BLOOD.

Specific Gravity.—Prepare a mixture of chloroform and benzol of a specific gravity of about 1.060, and add a drop of the blood. If the drop rises to the surface, add more benzol; if it sinks, add more chloroform. When the drop neither rises nor sinks, determine the specific gravity of the mixture.

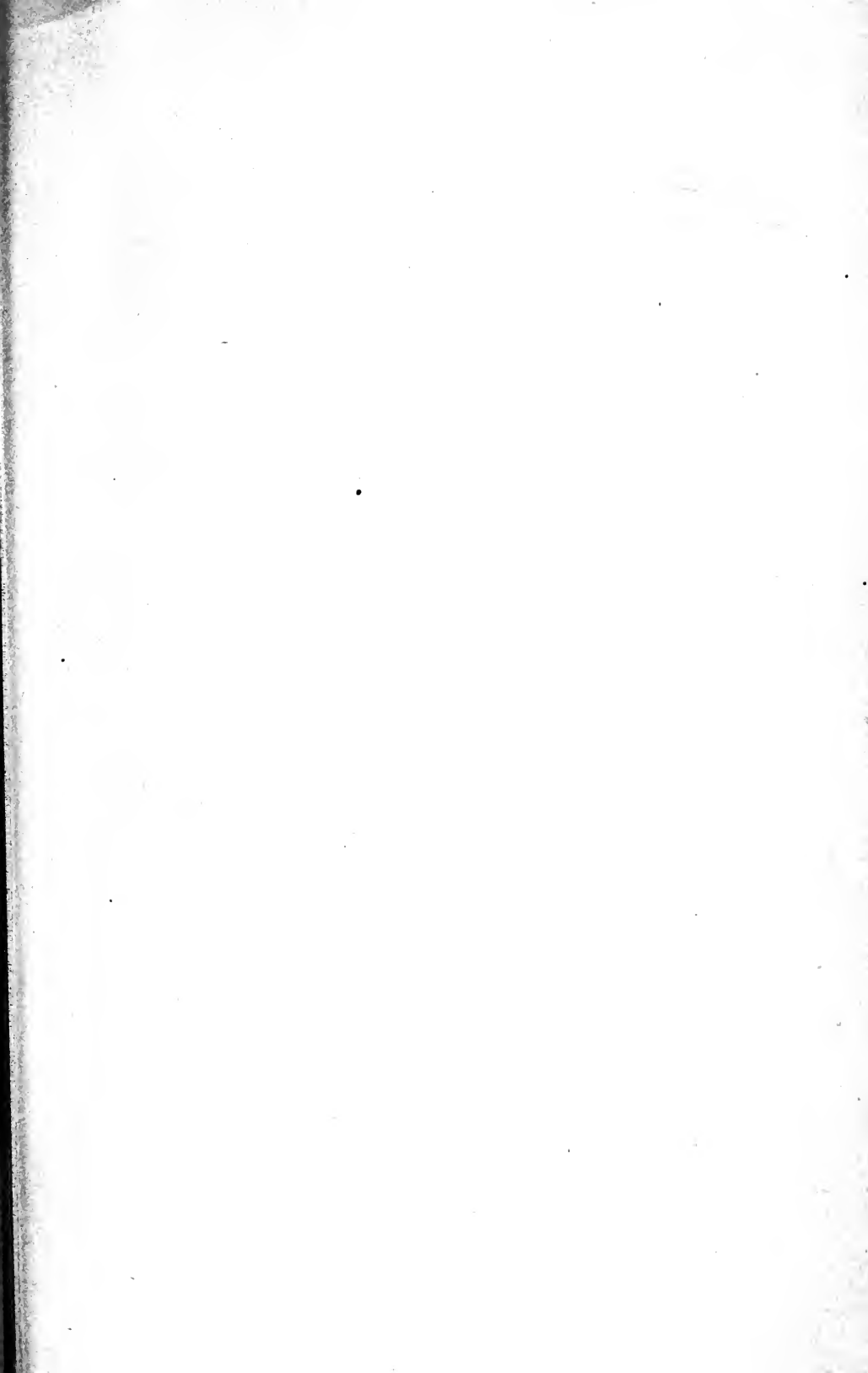
Enumeration of Corpuscles, by the hæmocytometer of Gowers or of Thoma. For dilution of the blood prepare a solution of sodium sulphate, 6.7 grammes, in 113.5 c.c. of water, with 3.5 c.c. of acetic acid, or use a 2.5 per cent. solution of potassium dichromate. Measure, by means of the special pipette, 995 cubic mm. of this solution into a small glass vessel. Prick the skin of the ear lobe, or of the finger, and draw up 5 cubic mm. of blood by means of a second, special, capillary pipette. Blow the blood from the pipette into the vessel containing the saline solution, and rinse out the pipette with the same solution. Stir the mixture.

and place one drop of it on the slide of the instrument. This slide is ruled into squares (in the Thoma cell each millimetre is divided into 400 squares in sets of 16) and so arranged that with the cover glass in position the blood film is one-tenth of a mm. in depth. Count the corpuscles in about 50 squares. Determine the average number per square and (in case of the Thoma cell) multiply this by 4000 to obtain the number of corpuscles per cubic mm. Multiply again by 200 to obtain the number of corpuscles per cubic mm. of undiluted blood. In one form of Gower's cell each square represents one-five-hundredth of a cubic mm., hence, the average number of corpuscles in each square, in this case (the blood being diluted 200 times as before), must be multiplied by 500×200 to obtain the number of corpuscles in one cubic millimetre of undiluted blood. For diluting the blood the Thoma-Zeiss apparatus has a pipette graduated at 0.5, 1.0, and 101. cu. mm. The blood is drawn up to the 0.5, or 1.0 mark, and the diluting liquid to the 101. mark. If 0.5 cu. mm. of blood is taken, the average number of corpuscles per square is to be multiplied by 4000×200 ; while if 1.0 cu. mm. of blood is taken, the number of corpuscles per square is to be multiplied by 4000×100 .

The proportion of white to red corpuscles may be approximately ascertained during the counting, the saline solution rendering prominent the nuclei of the white corpuscles. To differentiate the several kinds of white corpuscles, neutrophiles, eosinophiles, etc., it is necessary to prepare a stained specimen of the blood. For the methods of staining, and for description of these cells, see page 93 and text-books of histology.

The centrifuge with hæmatocrit attachment affords an easy and rapid approximate method for the enumeration of corpuscles. Ample instructions accompany the instrument.

Estimation of Hæmoglobin, by the hæmoglobinometer of Gowers. Two glass tubes are provided, one graduated into 120 parts for the blood, the other containing a preparation of glycerine jelly so tinted with carmine and picrocarmine that its color is that of normal blood diluted with 100 parts water. Twenty cubic mm. of blood are measured by means of a capillary pipette into a few drops of distilled water previously placed in the graduated tube. The blood is then diluted until the tint is the same as that of the standard. If the blood be diluted to the 100 mark then the hæmoglobin is normal; if to the 50 mark, then one-half normal,



etc. It is important to compare the amount of hæmoglobin with the number of red corpuscles. The percentage of hæmoglobin divided by the percentage of red corpuscles gives the *Color Ratio* or *Index*. Thus, in a case of chlorosis, the hæmoglobin was 30 p. c. of the normal, the red corpuscles were 90 p. c. of the normal and the Color Ratio, $\frac{30}{90}$ or 0.3 +.

Estimation of Hæmoglobin from the contained iron. Evaporate a weighed quantity of blood to dryness, ignite at a dull red heat, treat the residue with hydrochloric acid and determine the iron quantitatively. If x equal the percentage of iron, then the percentage of hæmoglobin in the sample equals x multiplied by 100, divided by 0.42.

TESTS FOR BLOOD.

The suspected solution may be examined microscopically for blood corpuscles, and spectroscopically for blood pigment. If the blood be fresh the spectrum of oxyhæmoglobin may be obtained; older blood will probably show methæmoglobin. In the case of stains on cloth, extract with a little water, add a few drops of sodium hyposulphite, NaHSO_2 , a few drops of strong sodium hydroxide, and then examine for the spectrum of hæmochromogen.

The Guaiacum Test. Mix the suspected fluid with 3–4 drops of a freshly prepared tincture of guaiacum resin. Float an ethereal solution of hydrogen dioxide on the surface of the mixture, and let it stand without shaking. In presence of hæmoglobin the ethereal layer will turn blue.

The guaiacum test is given, more or less perfectly, by substances other than blood, *e. g.*, by milk, pus, saliva, various mineral compounds, oxidizing agents, etc., but in most cases the blue color is obtained on addition of the guaiacum alone, while with blood no color is obtained until after the addition of the dioxide. Old oil of turpentine that has been well exposed to light and air may be used instead of the ethereal hydrogen dioxide solution.

The "Hæmin" and Other Tests. To a drop of fresh blood on a glass slide add a drop or so of glacial acetic acid and heat slowly to boiling. Cool and examine under the high power of the microscope for crystals of hæmatin hydrochloride, "hæmin," minute dark brown triclinic plates and prisms, often in star-shaped clusters.

In the examination of a stain on cloth, etc., scrape the stain and place the scrapings (or place a few fibres of the stained material)

on a large glass slide. Add 2-3 small crystals of sodium chloride, and a few drops of glacial acetic acid; warm gently for some time, then add, to the evaporated solution, two drops more of the acid, and heat to boiling. Cover with a cover glass and examine for the crystals. The treatment with acetic acid may advantageously be repeated several times.

As a sequel to the hæmin test, dissolve the crystals obtained, in a few drops of sodium hydroxide. If sufficient hæmin be present, the solution is dichroic, green and red. Evaporate to dryness in a small porcelain crucible and test the residue for iron.

A stain may be further tested as follows: Soak the stain in water and place drops of the aqueous solution on a number of watch glasses. To one add nitric acid, to another add acetic acid and potassium ferrocyanide; if the stain be recent, precipitates should be obtained in both tests. To a third portion add a drop of ammonium hydroxide; the red color remains, while with vegetable reds it would probably be destroyed. Heat to boiling—a gray turbidity is produced—add a few drops of sodium hydroxide—the turbidity disappears and the solution exhibits the green-red dichroism.

For tests for blood in the urine, see under Urine Analysis.



THE URINE.

Constituents of Normal Urine.—Urea and related substances; uric acid, xanthine, creatinine, etc. Compounds of fatty acids and traces of other non-nitrogenous substances, including carbohydrates. Aromatic substances; etherial sulphates of phenol, cresol, pyrocatechol, indoxyl and skatoxyl; hippuric acid, etc. Pigments and ferments. Mineral substances; chlorides, sulphates and phosphates of sodium, potassium, calcium and magnesium, ammonium compounds, and carbonates. Gases; nitrogen, carbon dioxide and traces of oxygen.

Abnormal Constituents.—Serum albumin and other proteids; blood and bile pigments, bile acids, abnormal urinary pigments; glucose, lactose, and glycuronic acid; leucin and tyrosin; fats, lecithin, cholesterol, cystin; blood corpuscles, pus, casts, renal epithelium, etc.

According to the author's analyses a man weighing 65 kilogrammes will pass, in 24 hours, an average of 1480 c.c. of urine with a specific gravity of 1020, the average amounts of the dissolved substances being about as follows: In a total of 60 grammes, we have—

Urea, . . .	34.0 grammes.	Chlorine, . . .	7.3 grammes.
Uric Acid, . .	0.6 “	Phosphorus Pen-	
Creatinine, . .	0.9 “	toxide, . . .	3.0 “
Hippuric Acid, .	0.7 “	Sulphur Trioxide, .	2.2 “
Other Organic		Potassium Oxide, .	3.0 “
Constituents, .	2.3 “	Sodium Oxide, . .	4.5 “
		Calcium Oxide, . .	0.3 “
Total Organic, .	38.5 grammes.	Magnesium Oxide, .	0.4 “
		Other Inorganic	
		Constituents, . .	0.8 “
		Total Inorganic, .	21.5 grammes.

GENERAL PLAN OF CLINICAL URINARY ANALYSIS.

- I. Ascertain Quantity passed in 24 hours, and obtain an average Sample.
- II. Note Color, Appearance and Odor.
- III. If turbid, test Character of Sediment.
- IV. Test Reaction with litmus paper.
- V. Determine the Specific Gravity.
- VI. Calculate the Total Solids.
- VII. Set aside a sample for Microscopic Examination; filter the remainder of the urine and use filtered urine for the following tests:
- VIII. Test for Mucin.
- IX. Test for Albumin, and, if present, determine amount. Heat the urine to boiling, cool, filter, and use the albumin-free filtrate for the following tests:
 - X. Test for Sugar, and, if present, determine the amount.
- XI. Determine the amount of Urea. (In albumin-free Urine.)
- XII. Determine the approximate amount of Chlorides.
- XIII. Determine the approximate amount of Sulphates.
- XIV. Determine the approximate amount of Phosphates.
- XV. Test for "Indican."
- XVI. Test for Bile and for Blood.
- XVII. Make Microscopic Examination of the Sediment.

NOTES ON THE CLINICAL ANALYSIS.

QUANTITY.

An adult man passes on an average, 1300 to 1600 c.c. of urine in 24 hours. Women secrete less than men; children absolutely less but relatively more, about 60 c.c. for each kilogramme of body weight (man, about 23 c.c. for each kilo). The urine is *increased* after the ingestion of much liquid, reaching 2000 to 3000 c.c. It is increased, also, in nervous excitement, hysteria, chorea, in forms of diabetes, in chronic interstitial nephritis, and in amyloid kidney. It is *diminished* by profuse perspiration, hence in summer, by abstinence from liquid food, by sleep, often in valvular disease, acute inflammations, fever, diarrhœa, enteritis, etc.; in acute nephritis, often in chronic parenchymatous nephritis, and in uræmia.

The sample selected for analysis, owing to variation in the com-





position of the urine during the day, should be an average of that passed. If the average sample is not obtainable, note the time of passing; night, morning, before or after a meal, etc.

COLOR, APPEARANCE AND ODOR.

Normal urine is described as clear, straw-yellow, sherry colored, or amber. It varies normally in shade from nearly colorless to dark amber. The pigment has been variously designated but may best receive the non-committal name of Urochrome. A modification of the normal pigment occurs in disease and is described as febrile Urobilin. The urine is *light colored* after ingestion of a large amount of water, in nervous conditions, and, generally, whenever the urine is greatly increased in amount; it is often nearly *colorless* in diabetes. It is *dark* after profuse perspiration, muscular activity, etc., and in acute febrile conditions. It may be *red* or *brown* from presence of blood pigments, or *greenish-yellow*, *brown*, to *black* from presence of bile. "*Blue*" urine is sometimes observed in cholera and in typhus. Again, the color may be due to drugs ingested; phenol and gallic acid, producing a *black* urine; santonin, chrysophanic acid, rhubarb, senna, etc., an *orange* to *yellow* urine; sulphonal, a *dark-red* urine.

In case the color be so pronounced as to interfere with the chemical tests, the urine should be decolorized by shaking with powdered animal charcoal and filtering.

The urine is usually clear when passed, though a faint cloudiness is not uncommon. All urines become turbid on standing. A turbidity may be due to an excess of mucus, to pus, chyle, semen, phosphates, urates, etc. By heating, the turbidity due to *phosphates* is slightly increased, but it disappears at once on the addition of a few drops of nitric acid or of acetic acid. By heating the turbidity due to *urates* disappears. If due to *pus*, the turbidity is increased by heat.

The *odor* of normal urine is described as *aromatic*. After standing, however, it may become *ammoniacal*. Asparagus, turpentine, cubebs, valerian, and garlic, all impart characteristic odors. The urine of diabetes has often a sweet odor, due generally to presence of acetone; that of albuminuria, after standing, a fetid odor.

REACTION.

The reaction of an average sample of normal urine is always

acid; the total acidity in terms of oxalic acid being 2–4 grammes for the 24 hours. The acidity is *reduced*, or the urine may become *alkaline*, after hearty meals, hot baths, administration of alkaline salts, etc., with a strictly vegetable diet, in general debility, chlorosis, or anæmia. The acidity is *increased* with a meat diet, by muscular activity, in fevers, typhus, and often in pneumonia.

Upon standing the urine may at first become more acid, with decomposition of urates, but later an alkaline fermentation sets in, the urea is decomposed and ammonium carbonate formed. At this stage the turbidity is increased by precipitation of phosphates, and an ammoniacal odor is noticeable.

Test the reaction of the urine with litmus paper. If an alkaline reaction be obtained (red litmus turns blue) dry and warm the paper. If the alkalinity be due to fixed alkalies the blue color will remain after warming and the alkalinity is referable to the blood. If the blue color disappears on warming, the alkaline reaction is due to the ammonium compounds formed in the urine by decomposition of the urea.

Total Acidity of the Urine.—To 50 c.c. of urine add several drops of phenolphthalein, and titrate with decinormal potassium hydroxide until the pink color appears. Each c.c. of the decinormal alkali is equivalent to 0.006285 grammes of oxalic acid. Assuming that the 50 c.c. of urine weigh 50 grammes, the percentage may be easily calculated. In case the urine is highly colored, it is best first to remove the color by shaking with purified animal charcoal and filtering.

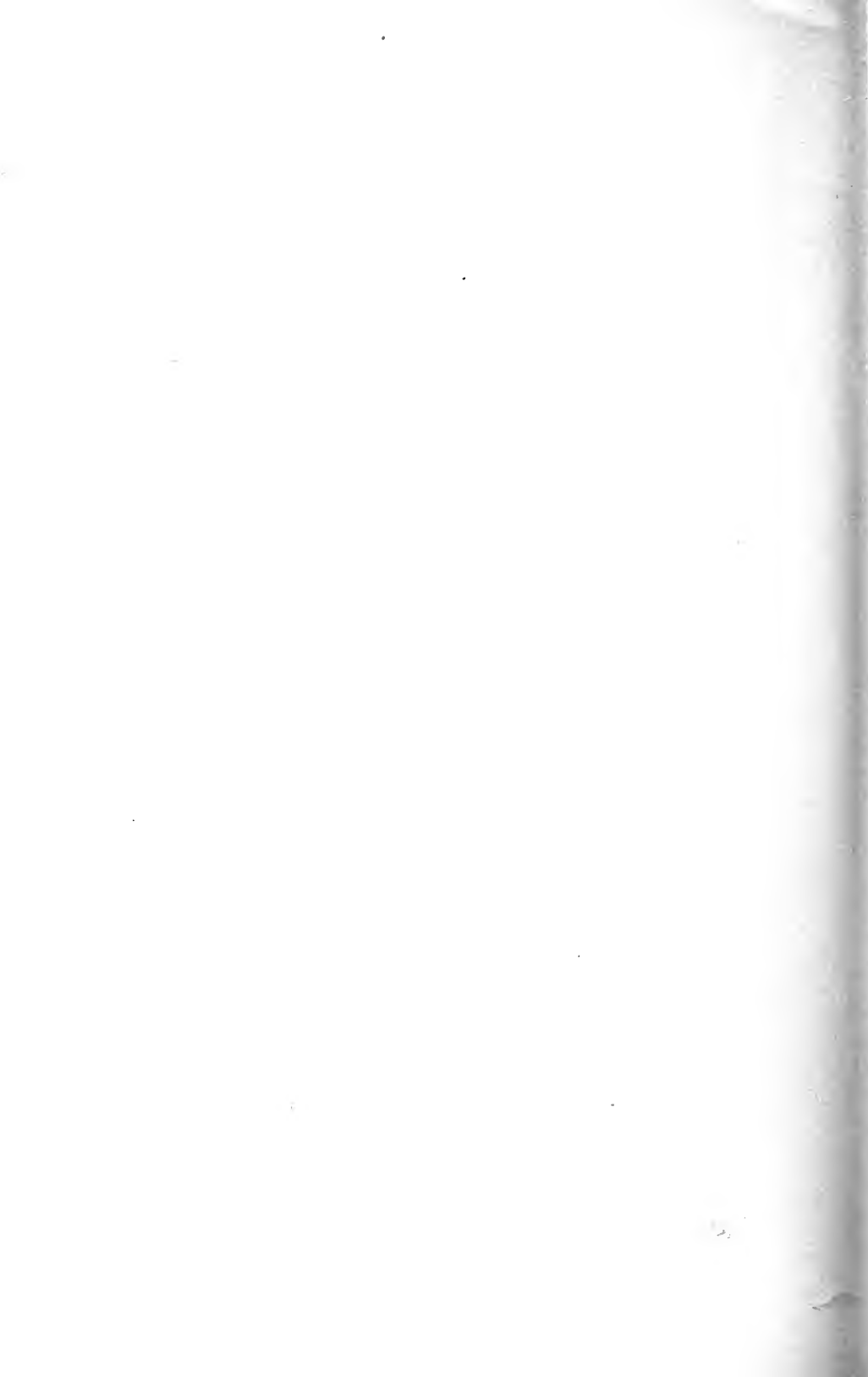
It is to be remembered that the acid reaction of the urine is in reality due to the presence of acid salts, NaH_2PO_4 , etc., and not at all to oxalic acid, this last substance being generally adopted, however, because of the greater ease in calculation and as affording a simple means of comparison.

SPECIFIC GRAVITY.

The specific gravity of normal adult urine varies generally between 1010 and 1030, with an average of 1020 for 1500 c.c. passed. In children from two to thirteen years of age the average is about 1012.

In order that the determination of the specific gravity shall be of value, it is necessary to know the amount passed and to use an average sample.





When the amount passed varies from the normal (1500 c.c.) the specific gravity of the average sample may be reduced to the normal by the formula:—

$$\frac{A \times G}{1500} + 1000 = D$$

In which A equals the amount passed, G equals the last two figures of the observed specific gravity, and D equals the specific gravity of the urine reduced to the normal quantity. Thus, suppose 3000 c.c. were passed, and the specific gravity of the average sample to be 1015.

$$\frac{3000 \times 15}{1500} + 1000 = 1030$$

Reduced to the normal, then, of 1500 c.c., the specific gravity is 1030, showing that while the specific gravity of the original sample was low, the total solids are in reality high.

Note, however, that in calculations, *e. g.*, in calculating the total solids, the observed, not the revised, specific gravity must be used.

Considered with the amount passed in 24 hours, the specific gravity gives the following indications: A *decreased amount* with *increased specific gravity* indicates diminished secretion, loss of water by other excretions, or the presence of some morbid process, acute nephritis, fever, etc. An *increased amount* with *decreased specific gravity* indicates abundant ingestion of water, absorption of exudations, or some form of diseased kidney. A *decreased amount* with *decreased specific gravity* indicates, possibly, uræmia, or chronic parenchymatous nephritis. An *increased amount* with *increased specific gravity* may indicate diabetes mellitus.

The specific gravity is usually determined by means of the urinometer, a small hydrometer with special scale. This scale is adjusted to give accurate readings at a certain temperature (usually 60° F.) marked upon the instrument, and as the temperature of the urine tested is nearly always above this, it is necessary, in accurate determinations, to make a corresponding correction. The temperature of the urine is determined and for each 6° above 60° F., *one* is added to the observed specific gravity. Thus the corrected specific gravity for a urine reading 1020 at 72° F. is 1022. For more accurate determinations it is necessary to use the pycnometer, for which, see works on physics.

TOTAL SOLIDS.

The solids in the normal urine of 24 hours vary from 45–65 grammes, with an average for the male adult of about 60 grammes (926 grains). In practice, however, age, sex, diet and exercise

must be considered, and a proper figure adopted for each case under observation. For differences in age, deduct one-tenth for each ten years after forty. For light diet or for fasting, deduct from one-tenth to one-third. For confinement to bed, deduct one-tenth; for confinement to the house, deduct one-twentieth. The solids may be calculated with sufficient accuracy for clinical purposes by multiplying the last two figures of the specific gravity by Häser's coefficient, 2.33. The product gives the number of grammes in 1000 c.c. of the urine, and from this the number of grammes in the urine passed may be easily calculated. Other factors, or coefficients, which have been proposed are, Trapp's = 2, and that of Loebisch = 2.2. Häser's coefficient is that most often used, though probably the coefficient of Loebisch, or the even simpler one of Trapp, will give nearer to the true amount of total solids. For the urine of young children, the coefficient 1.80 should be used. In English measure the number of grains of total solids in 24 hours may be roughly calculated by multiplying the last two figures of the specific gravity by the number of fluid ounces passed.

MUCIN.

Mucin is present in small amount in normal urines, but it is greatly increased by irritation of the urinary tract. It is precipitated by addition of acetic acid in the cold (unlike albumin). Mucin is not precipitated by boiling, but is precipitated by dilute mineral acids, as well as by acetic, citric, and other organic acids. Mucus in excess in acid urine presents itself as a flocculent amorphous mass, easily soluble in sodium hydroxide. See, also, under Urinary Sediments.

ALBUMIN.

Normal urine is free from proteids, but, on the other hand, the presence of a trace of albumin is not necessarily always of serious import. Temporary albuminuria may occur after severe bodily exertion, after the shock of a cold bath, from excess of albuminous foods, from the presence of semen, etc. When more than a trace is present, or when this trace persists for a considerable time, the existence of a serious abnormal condition is indicated. Serum albumin and serum globulin are the forms of proteid most frequently met with, while hæmoglobin, fibrinogen, peptones and proteoses may also appear. In general, the immediate cause of



albumin in the urine may be stated as impaired circulation through the glomeruli of the kidney, a result of either venous or arterial disorder, of changes in the blood itself, or of diseased condition of the kidney. The albuminuria of pregnancy, like that due to ovarian or uterine tumors, is generally a result of disordered venous reflux, and the same may be said of the albuminuria of heart disease. Albumin may occur in gout, in scarlet fever, diphtheria, pneumonia, and as a result of irritant poisoning. It is typical in Bright's disease. In acute parenchymatous nephritis there is considerable albumin and often blood, the urine is decreased and the specific gravity is high. In chronic parenchymatous nephritis there is considerable albumin, the urine is normal or decreased, and the specific gravity is generally low. In chronic interstitial nephritis the urine is increased, the specific gravity is low, and the albumin is small in amount. In amyloid degeneration the urine is increased, the specific gravity is low, and there is considerable albumin. In acute interstitial nephritis both the amount of urine and the specific gravity are decreased, while the albumin is variable.

Among other diseases giving rise to albuminuria may be mentioned cystic disease of the kidney, acute and passive renal hyperæmia, renal tuberculosis, calculus, uræmia, hydronephrosis and pyonephrosis.

HEAT TEST. A long test-tube is three-quarters filled with clear acid urine and the upper half of this is carefully heated to boiling. A cloudiness appearing in the heated portion may be due to albumin or to phosphates. Add a few drops of dilute nitric acid, phosphates will be dissolved and any cloudiness remaining will be due to albumin.

Precautions.—If the urine is not already acid, acidify, before heating, by addition of a few drops of dilute nitric acid. Acetic acid may be used, but has the double disadvantage of being more likely to cause the solution of a trace of albumin than nitric, and also of precipitating mucin. A cloudiness appearing only after some minutes may be due to albumoses. Urates, if abundant, sometimes separate on cooling, but are not likely to be mistaken for albumin. The addition of nitric acid after boiling should be continued until one drop has been added for each c.c. of urine.

NITRIC ACID CONTACT TEST. Place some pure nitric acid in a test-tube, and float over it carefully, by means of a pipette, an

equal volume of the urine to be tested. A white zone or ring at the contact of the two liquids indicates albumin.

Precautions.—A pink, red, or brown color may appear at the contact, due to action of the acid on the coloring matters of the urine. When cold acid is used in the test, crystalline nitrate of urea may separate at the contact, or acid urates may cause a cloudiness just above. Resinous matters, if present, as after ingestion of turpentine, balsams, etc., may cause a yellowish-white zone, which is unlike albumin, however, in being soluble in alcohol. Albumose is precipitated by nitric acid in the cold, dissolves on heating, and reappears when cooled.

FERROCYANIDE TEST. To a little acetic acid in a test-tube add 2-3 volumes of potassium ferrocyanide, and then add the urine. Albumin is separated as a milky or flocculent precipitate. Purdy claims that this test is given by albumin and its modifications, but not by other urinary ingredients.

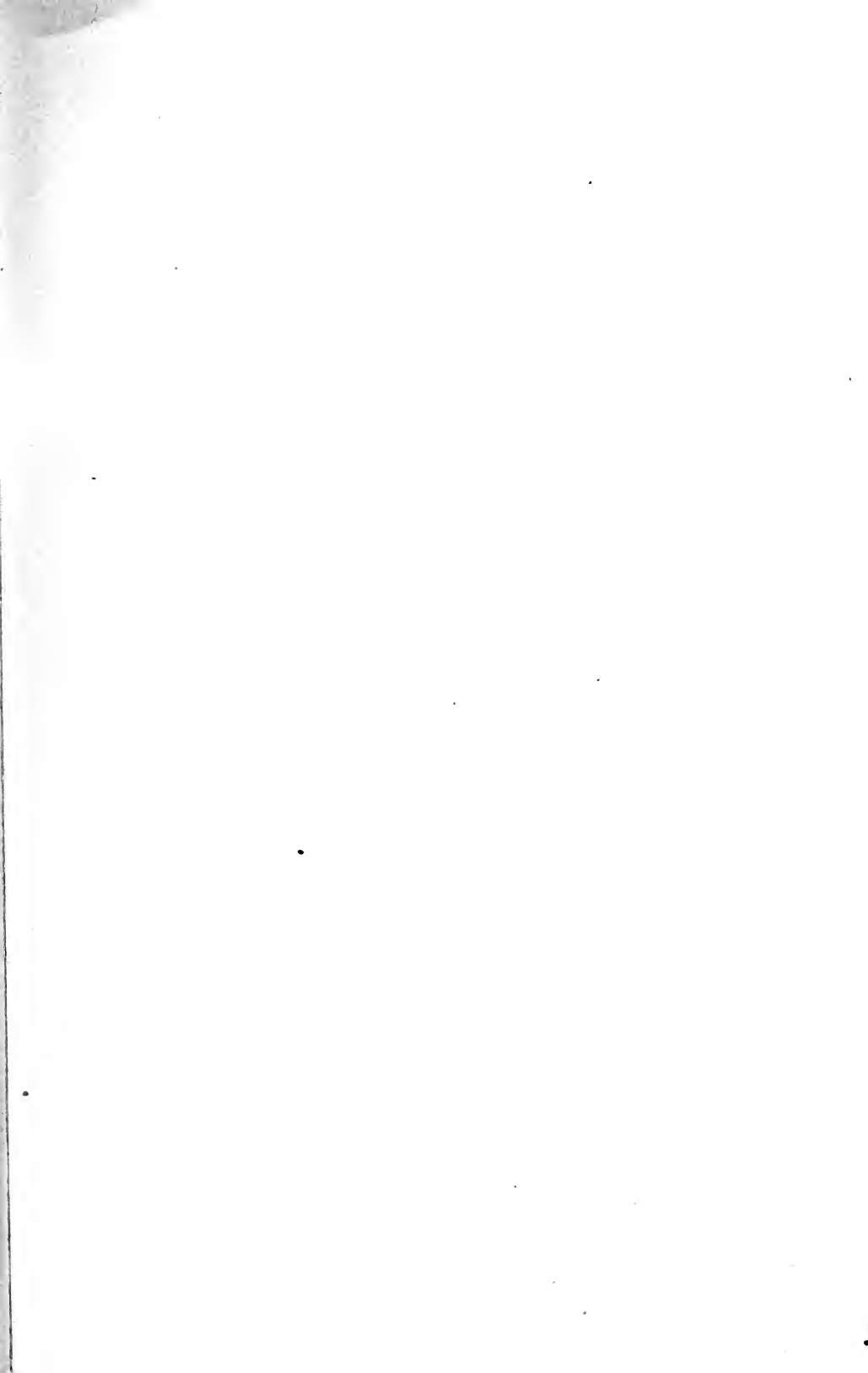
PICRIC ACID TEST. Warm some picric acid solution in a test tube and add the urine to it, drop by drop. A slight opalescence as each drop of urine enters the acid indicates albumin. This test may also be performed by the contact method, floating the acid over the urine.

Precaution.—If cold acid be used, peptones, mucin, and alkaloïds, may also be precipitated. With the warm acid the test is exceedingly delicate.

In a highly acid urine picric acid may cause the separation of urates, and, sometimes, of uric acid.

For other tests, see Albumin, p. 78.

QUANTITATIVE ESTIMATION. The quantitative estimation of albumin is difficult, and an accurate determination is rarely possible in the ordinary clinical analysis. A rough comparison of the amount of albumin in the urine from day to day may be made from the bulk of coagulum obtained by the heat test, using always the same size tube and the same amount of urine. A more accurate estimation may be made with *Esbach's Albuminometer*. The urine, diluted with a known volume of water, if there be much albumin, is introduced into the tube to the mark U, and Esbach's reagent (see Appendix) added to the mark R. The reagent is mixed with the urine, the tube stoppered and allowed to stand 24 hours. The volume of the precipitate measured by the graduations, gives the percentage of albumin. Each main division equals



0.1 per cent. There is rarely more than 1.0 per cent. of albumin present.

A still more accurate method is the following: The urine is diluted with 9 volumes of water, and from this diluted urine (one-tenth urine) test solutions are prepared, each containing 10 c.c. of water and a measured volume of the one-tenth urine; *e.g.*, (1) Contains 10 c.c. of water plus 1 c.c. of the one-tenth urine; (2) Contains 10 c.c. of water plus 2 c.c. of the one-tenth urine, etc. Nitric acid contact tests are now made with each test solution until one is found which responds only after standing for 2-3 minutes. The percentage of albumin in the original urine may be calculated from the formula:

$$\frac{10 + V}{30 V} = P.$$

In which V equals the volume of one-tenth urine added to the 10 c.c. of water, and P equals the percentage sought. For instance, if to the test solution, which produces a zone of coagulum only after standing 2-3 minutes, 5 c.c. of the one-tenth urine had been added, then the percentage of albumin originally present is

$$\frac{10 + 5}{30 \times 5} = 0.10 \text{ per cent.}$$

SUGAR IN URINE.

Transitory glycosuria may occur in cerebro-spinal meningitis, in epilepsy, from brain injuries, under the influence of strong emotion, in pneumonia, ague, gout, in cholera, in disease of the pancreas, and after excessive use of saccharine food. Lactose is frequently present in the urine of mothers during the weaning period. Cane sugar may appear after ingestion of large quantities of that carbohydrate. *Permanent glycosuria* is generally considered as indicative of diabetes. In general, diabetic urine is pale straw-colored, with sometimes a greenish tint; it is often turbid and may have a sweetish odor. The specific gravity is high (1030-1050) and the quantity passed is seldom less than 1600 c.c. in 24 hours. It may vary, however, between the extreme limits of 500 c.c. and 8000 c.c. Diabetes mellitus with polyuria, is far more serious than without, and, indeed, glycosuria without polyuria does not seem to be necessarily fatal. The percentage of sugar varies from 2-3 per cent. to 12 per cent.

TROMMER'S TEST. Add to the urine in a test-tube about one-fourth its volume of sodium hydroxide, and then dilute copper sulphate, drop by drop, until a slight permanent precipitate is formed. In the presence of glucose the bluish-white precipitate of cupric hydroxide first formed dissolves on agitation, producing a dark-blue solution. Heat the liquid and, in presence of glucose, yellow cuprous hydroxide and red cuprous oxide are precipitated just as the liquid begins to boil. The same precipitation takes place without heating, but much more slowly.

Precautions.—A normal urine will often decolorize the solution, but no red precipitate is formed. The sodium hydroxide causes a precipitation of flocculent phosphates, which, however, bear no resemblance to the granular cuprous precipitate. A precipitate of yellow cuprous hydroxide, which separates on the cooling of the test, may not be due to sugar. Uric acid, hippuric acid, creatinine, xanthine bases, and mucin may cause a partial reduction of the copper solution. Glycuronic acid produces a complete reduction. The presence of albumin, peptones, etc., interferes with the delicacy of the test. When there is but a slight reduction, greater accuracy may be attained by clarifying the urine with animal charcoal or lead acetate, filtering, and testing the filtrate.

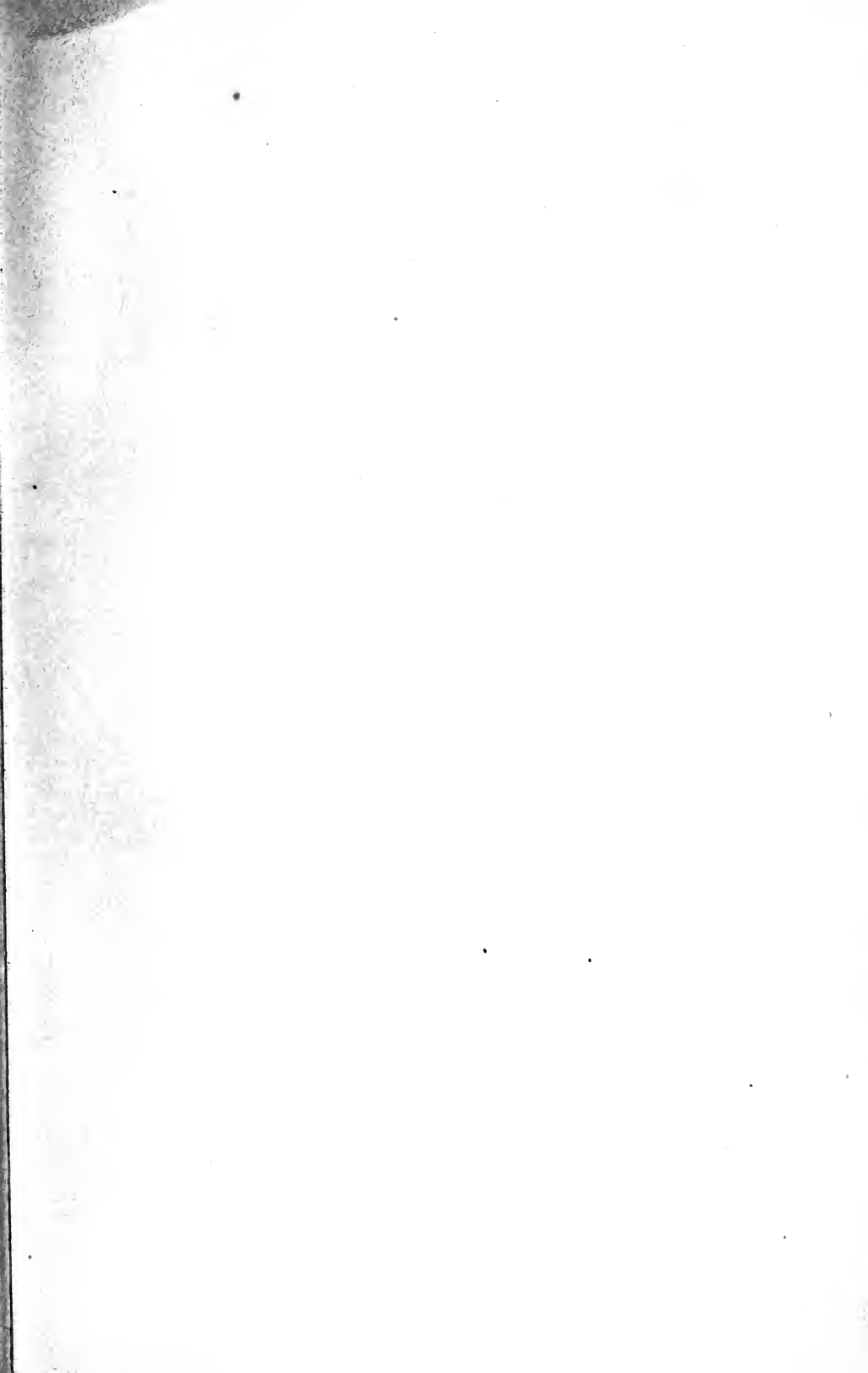
FEHLING'S TEST, HAINES' TEST, ETC. (See Appendix for the solutions.)

Boil four or five c.c. of the solution in a test-tube and add the urine drop by drop. A yellowish-red precipitate, as in Trommer's test, indicates glucose.

Precautions.—The test solution, which, in the case of Fehling's, is to be diluted with about three volumes of water, should remain clear when boiled before addition of the urine. In Haines' test not more than about eight drops of urine should be added. The precautions given under Trommer's test apply here also, and should be carefully observed.

As regards the relative value of Haines' and Fehling's solutions, it may be remarked that Haines' solution is less liable to decomposition than is Fehling's *completed* solution. It is best, however, to preserve Fehling's solution in two parts, as described in the Appendix, and to mix only a sufficient amount for each test.

BÖRTGER'S BISMUTH TEST. To a few c.c. of the urine in a test-tube, add an equal volume of sodium hydroxide and a few grains of bismuth subnitrate. Mix well and boil for several minutes.



In presence of glucose, black metallic bismuth will be precipitated. A rather more delicate reaction is obtained by using the ALMEN-BÖTTGER TEST (Nylander's). Ten c.c. of urine are boiled with 1 c.c. of Almen's reagent (see Appendix); black metallic bismuth is separated.

Precautions.—Albumin, if present, will cause the precipitation of black bismuth sulphide. Many normal urines will cause a slight darkening of the bismuth subnitrate, such as might be produced by a trace of sugar.

PHENYL-HYDRAZIN TEST. To 50 c.c. of urine add 2 grammes of phenyl-hydrazin hydrochloride, and 4 grammes of sodium acetate. Dissolve the reagents in the urine and heat on the water bath for one hour. In presence of glucose fine yellow crystalline needles of glucosazone separate out on cooling.

Precautions.—A similar precipitate is given by other carbohydrates, and under certain circumstances by glycuronic acid. It may be necessary to examine the precipitate microscopically for the characteristic crystals, or even to determine their melting point (204° – 205° C.) in order to positively identify them.

FERMENTATION TEST. (See p. 70.) This test is useful in identifying glucose in presence of other reducing substances, as, for instance, in distinguishing glucose in presence of glycuronic acid. It is not, however, to be relied upon when but a small amount of glucose is present.

INDIGO-CARMINE TEST. (See p. 70.) This is an exceedingly delicate test, but gives a faint reaction with nearly all urines.

ALPHA-NAPHTHOL TEST. (See p. 71.) A delicate test and often recommended, but, like the last test named, it is given by nearly all urines.

QUANTITATIVE DETERMINATION. *By Fehling's Solution.*—Ten c.c. of Fehling's solution (see Appendix) are measured into a porcelain dish with 30 to 40 c.c. of water. The diluted solution is heated to boiling and the urine added from a burette until the blue color of the Fehling's solution has entirely disappeared. Note the number of c.c. of urine required to produce this result, and calculate the amount of glucose present, by the formula $\frac{5}{U} = P$, in which U represents the number of c.c. of urine added to produce complete decomposition, and P equals the percentage of glucose in the sample. From this the amount passed in the 24 hours urine can be calculated. When considerable sugar is present, it is

well to dilute the urine with a known volume of water, to determine the glucose in the diluted sample, and then to calculate back to the original.

By Purdy's Ammoniacal Copper Solution.—Dilute the urine with two or three volumes of water carefully measured. Place 35 c.c. of the test solution (see Appendix) in a 200 c.c. flask, add about 70 c.c. of water, boil, and from a burette, add the diluted urine until the blue color of the solution is just destroyed. The 35 c.c. of Purdy's solution are decolorized by 0.02 gramme of glucose. From the number of c.c. of urine required to produce the result, calculate the amount of glucose present, first in the diluted and then in the undiluted urine.

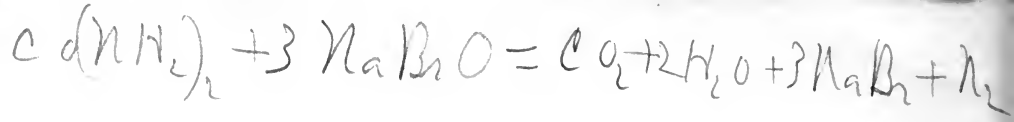
Pavy's ammoniacal copper test is very similar to the above, and is sufficiently described in the Appendix. Purdy's method is a highly satisfactory one for clinical purposes, though, in skilled hands, Fehling's is unsurpassed. The fermentation processes, which follow, are not to be recommended unless reducing substances other than glucose are known to be present. Approximate results only are obtained.

Roberts' Fermentation Method.—After a careful determination of its specific gravity (to the third decimal), the urine, together with a small piece of compressed yeast, is placed in a loosely-stoppered flask and left for 24 hours. The alcohol and carbonic anhydride produced by the fermentation, reduce the specific gravity of the solution one degree for each grain of sugar per fluid ounce. At the end of the operation the specific gravity is again determined, the loss representing the number of grains of sugar per fluid ounce. This number multiplied by 0.23 gives the *percentage* of glucose in the sample. It is well to make a parallel test on a sample without sugar, observing any variation that may occur in its specific gravity.

Einhorn's Method.—Ten c.c. of the urine are shaken with about 1 gramme of compressed yeast, and the mixture introduced into Einhorn's apparatus, a small graduated tube of special form. The carbonic anhydride gas evolved is measured at the end of 24 hours, its volume expressing directly, by the graduations on the tube, the percentage of glucose present.



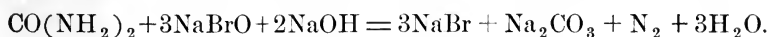
The urea varies in normal urine from 20 to 40 grammes (309 to



617 grains) in the 24 hours, with an average for men of about 34 grammes* (535 grains). It is to be noted that this average is for an adult male under forty years of age. Age, sex and conditions must be considered in deciding upon a normal average for each individual under examination. For variations from normal conditions deductions may be made in the proportions given under the total solids, page 104. Women secrete less than men, children absolutely less, but relatively, *i. e.*, in proportion to body weight, more. The urea is *increased* by a nitrogenous diet, by mental and, possibly, physical activity, at the beginning of the crisis in fevers, in ague, in diabetes, in pleurisy, and in acute tuberculosis. The urea is *decreased* by profuse perspiration, by diarrhœa, in cholera, in all forms of Bright's disease, in diabetic coma, in anæmia, and generally, in most chronic debilitating disorders. Expressing, as it does, the progress of nitrogenous metabolism in the body, the determination of the urea passed is important.

Approximate Estimation.—When the chlorides are normal and when sugar and albumin are absent, the urea may be taken as one-half the total solids.

Hypobromite Method.—There are several applications of this method, depending on differences in the form of apparatus used; the principle is the same, however, in all. A solution of sodium hypobromite containing an excess of sodium hydroxide (see Appendix) is added to the urine; the urea is decomposed, nitrogen gas is set free, and sodium bromide and carbonate are formed.



The nitrogen evolved is measured and, from its volume, the percentage of urea calculated.

A solution of chlorinated soda with potassium bromide may be used in place of the alkaline hypobromite, thus avoiding the rather offensive fumes of bromine. (See Appendix for the solution.)

Twenty c.c. of fresh hypobromite solution (40 c.c. of the chlorinated soda) are placed in a bottle, and the measured urine, contained in a small test-tube, is introduced in such a manner that the tube will stand in the bottle without spilling. The bottle is then connected by means of a perforated stopper and rubber tube with the top of an inverted burette standing in a jar of water. All

* Dr. Clifford Mitchell, of Chicago, considers this average high. As a result of his analyses he gives, for men, 26.5 grammes, for women 20.5.

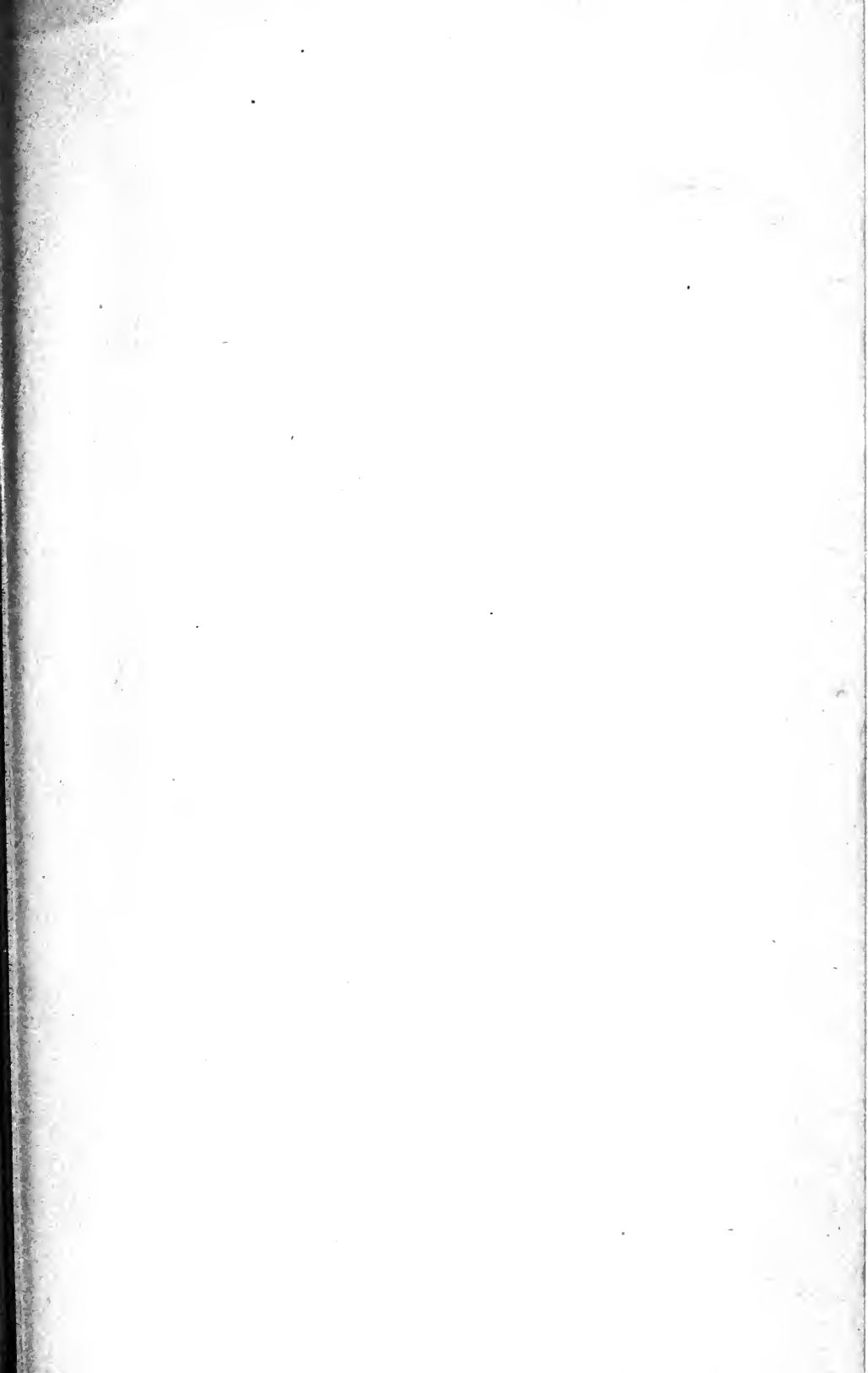
connections are carefully made, and the volume of air in the burette read from the graduations. The urine is now slowly mixed with the hypobromite, nitrogen gas is evolved, and a corresponding volume of air is driven from the bottle, displacing the water in the burette. When the evolution of gas has ceased, let the apparatus stand for a few minutes, and then measure again the air in the burette. The increase in volume represents the volume of nitrogen given off. The observed increase, in c.c., multiplied by the factor 0.0027, gives the weight in grammes of urea in the sample taken; *e. g.*, if 4 c.c. of urine were used for the test, and 21 c.c. of nitrogen were evolved, then we have, $0.0027 \times 21 = 0.0567$ gramme of urea in 4 c.c. of urine, or, 1.42 per cent. ($0.0567 \div 4 \times 100$).

Theoretically the factor employed should be 0.00268, but as the theoretical volume of nitrogen is not given off, 0.0027 gives more accurate results. In reading the volume of gas in the burette it is of course necessary that the latter shall be raised or lowered so as to bring the water on the same level inside and out.

The *Ureameter* devised by Prof. Doremus, of N. Y., is convenient, and in its latest form, with a side tube for accurate delivery of the urine replacing the pipette formerly used, it yields excellent results. The long arm of the instrument is nearly filled with the alkaline solution of sodium hypobromite, water is added to cut off the elbow leading from the bulb, and then one c.c. of urine is carefully introduced at the foot of the long arm. The percentage of urea is read directly from the graduations on the tube.

URIC ACID, $\text{H}_2\text{C}_5\text{H}_2\text{N}_4\text{O}_3$, AND URATES.

Uric acid, averaging from 0.3 to 0.8 gramme, is normally present in the urine in combination, as a urate. It is *increased* in pneumonia, indigestion, acute rheumatism, in leucocythæmia, by excessive meat diet, by lack of exercise, and in disorders of the circulation and respiration. It is *decreased* in most chronic diseases, in the later stages of Bright's disease, in diabetes, in gouty affections, and in chronic rheumatism. It is to be remembered that the appearance of a deposit of uric acid, or of urates, does not necessarily point to an excess of these ingredients. High acidity of the urine, and a decrease in mineral salts, tend to produce a separation of uric acid equally with the presence of an increase of that substance. The deposits are easily recognized. (See under Urinary Sediments.)





Uric acid may be separated from the urine as follows: To 200 c.c. of urine add 20 c.c. of strong hydrochloric acid and let the mixture stand 48 hours. Collect the sediment on a previously weighed filter paper, wash with cold water, dry and weigh. The increase in weight represents uric acid.

To detect uric acid or urates apply the *Murexid Test*. Evaporate the sediment with a drop of nitric acid. A yellow residue is obtained, which, when moistened with a drop of ammonium hydroxide, turns to a purple-red.

Determination of Uric Acid. Bartley's Method.—To 50 c.c. of clear urine add 5 c.c. of magnesium mixture (see Appendix) and about 10 c.c. of ammonia, Sp. Gr. 0.96. Warm and add, from a burette, a fiftieth-normal solution of silver nitrate. From time to time remove a drop of the solution and test on a porcelain plate with a weak solution of sodium hydrogen sulphide. The appearance of a dark cloud indicates the end reaction. Deduct 0.5 c.c. from the amount of silver nitrate used and multiply the remainder by 0.00336 (the equivalent of each c.c. of fiftieth-normal silver nitrate in terms of uric acid). From the result, the amount of uric acid in the sample, the percentage may be easily calculated.

Hopkin's Method.—Saturate the urine with crystalline ammonium chloride, filter off the precipitated ammonium urate, wash with a saturated solution of ammonium chloride, dissolve in weak alkali, neutralize with hydrochloric acid, and collect the uric acid on a weighed filter.

CHLORIDES.

The chlorine of the 24 hours urine varies from 6 to 10 grammes, equivalent to 10 to 16 grammes of sodium chloride. The average for an adult man may be placed at 7 grammes chlorine (11.5 grammes sodium chloride), for women, at 6 grammes chlorine, and for children, about 5 grammes chlorine. The amount varies during the day, being *increased* several hours after a full meal, and by mental or physical labor. It is *diminished*, in most fevers (increasing again just before or just after the crisis), in pneumonia, pleurisy, typhoid, cholera, and in many chronic diseases.

Approximate Estimation.—To the urine in a test-tube add a few drops of dilute nitric acid and 2-3 drops of a 10 p. c. solution of silver nitrate. If the chlorides be high or normal, a curdy white precipitate is formed; if low, only a milky cloudiness.

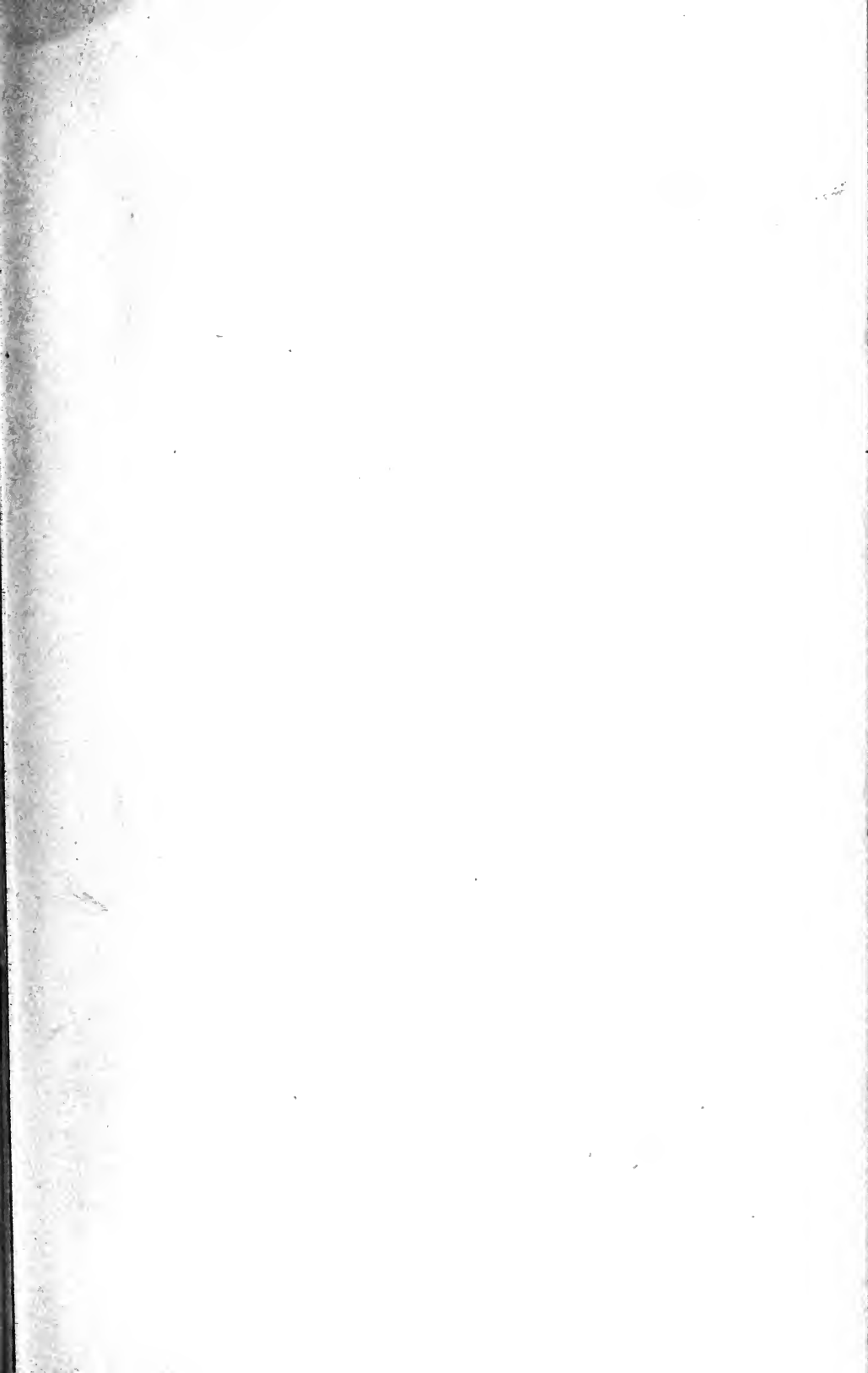
Accurate Determination.—The general method of chlorides (p. 64) may be applied to the urine, using a 10 c.c. sample and diluting with water. The number of c.c. of deci-normal silver nitrate used multiplied by 0.003537, will give the weight of chlorine in the sample, and from this the percentage may be calculated. Should it be desirable to report in terms of sodium chloride, multiply by 0.005837 instead of by 0.003537. In the application of this test to the urine there are, however, unavoidable errors, and the following—*Volhard's Method*, is preferred. The solutions required are, in addition to the Deci-normal Silver Nitrate, Ferric-Ammonium Sulphate (Ferric-Alum)—10 grammes dissolved in 100 c.c. of water, and, Deci-normal Potassium Sulphocyanate Solution—Dissolve 10 grammes of potassium sulphocyanate in one litre of water. Introduce into a flask 10 c.c. of deci-normal silver nitrate, 0.5 c.c. of ferric-alum solution, and 5 c.c. dilute nitric acid. Add the sulphocyanate from a burette until there is produced a faint brownish-red color which does not disappear on shaking. Note the number of c.c. of sulphocyanate used, and then dilute the remainder until one c.c. is exactly equivalent to one c.c. of deci-normal silver nitrate.

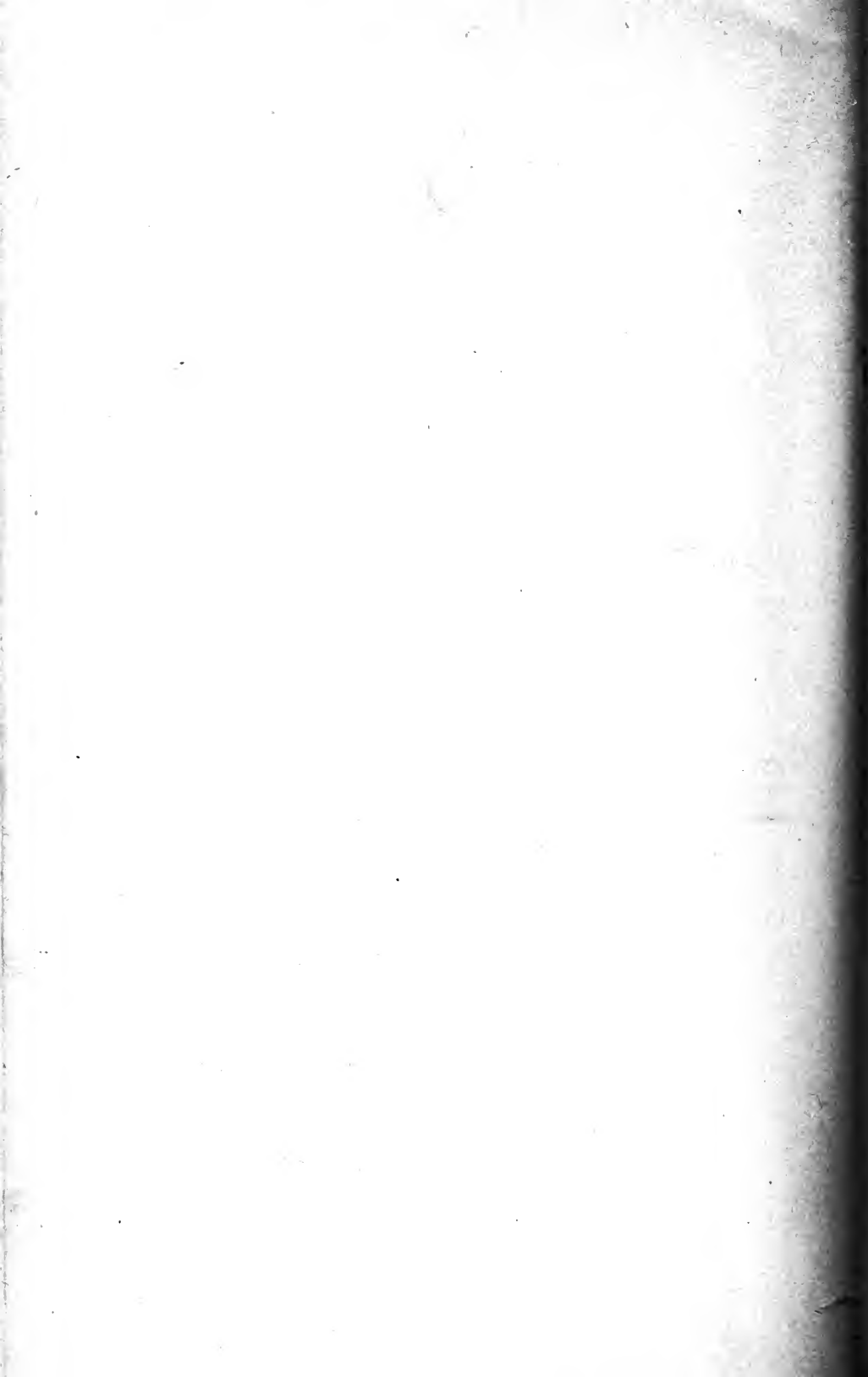
The process of analysis is then as follows: In a 150 c.c. flask place 3.537 grammes (about 3.4 c.c.) of urine, 3 c.c. nitric acid, and 20 c.c. water. Add 10 c.c. deci-normal silver nitrate, exactly measured, and shake the mixture. Add 0.5 c.c. ferric-alum solution, and then, from a burette, the deci-normal sulphocyanate until the appearance of a faint, permanent, brownish-red coloration indicates the end of the reaction. Subtracting the number of c.c. of potassium sulphocyanate added from the 10 c.c. of silver nitrate used, we ascertain the amount of silver nitrate required to precipitate the chlorides of the sample. Each c.c. so required represents 0.10 per cent. of chlorine in the urine.

For sodium chloride, multiply the chlorine found by 1.65, or modify the above test, using 5.837 grammes (about 5.7 c.c.) of urine and 15 c.c. of silver nitrate. Each c.c. of decinormal silver nitrate then required for the precipitation corresponds to 0.10 per cent. of sodium chloride.

SULPHATES.

Sulphuric acid is found in the urine combined with both organic and inorganic bases, the latter combination being normally in





excess of the former. Calculated to sulphur trioxide, the sulphates vary in normal urine from 1.5 to 3 grammes daily, with an average of about 2.2 grammes. The sulphates are *increased* by animal food, by physical activity, by ingestion of sulphur compounds, in acute inflammatory diseases, pneumonia, acute rheumatism, delirium, and often in diabetes insipidus. They are *decreased*, with diminished metabolism in chronic affections, in leucæmia, and in diabetes mellitus.

Approximate Estimation.—Add to the urine a few drops of dilute hydrochloric acid and one-fourth volume of barium chloride. An opaque milky cloudiness indicates normal sulphates; an opaque creamy precipitate, increased sulphates; a faint semi-transparent cloudiness, diminished sulphates.

SULPHATES OF ORGANIC BASES. Sulphates of phenol, cresol, pyrocatechol, indol, skatol, etc. These compounds are derived partially from the food, but are interesting chiefly as putrefaction products absorbed from the intestine. In normal urine they are present in small amount, probably about 10 per cent. of the total sulphates, but in certain stomach troubles, in disordered absorption, and from abnormal fermentative and putrefactive changes, they may be considerably increased.

Determination of Organic Sulphates.—100 c.c. of the urine are mixed with 100 c.c. of Barium Mixture (see Appendix), and the precipitate formed filtered off. An aliquot part of the filtrate is acidified with hydrochloric acid and boiled. It is then heated to 100° C. for an hour, allowed to stand until completely settled, and finally filtered through an ashless paper. The precipitate is dried, ignited and weighed. The weight of barium sulphate found multiplied by 0.34335 gives its equivalent in terms of sulphuric anhydride.

The Total Sulphates may be determined by acidifying the urine with hydrochloric acid, boiling, and adding barium chloride until all is precipitated. The precipitate is then treated as described above.

PHOSPHATES.

The phosphates of the urine may be divided into two classes, the *alkaline phosphates*, phosphates of sodium and potassium ($\frac{2}{3}$); the *earthy phosphates*, phosphates of calcium and magnesium ($\frac{1}{3}$). The latter are subject to but little variation in disease. The *total*

phosphates calculated as phosphorus pentoxide, vary in normal urine from 2.5 to 3.5 grammes, with a daily average of 3 grammes. They are *increased* in acute inflammatory diseases, in the early stages of acute fevers, in phthisis, leucaemia, osteomalacia, and sometimes in diabetes. They are *decreased*, in many chronic brain troubles, in epilepsy, general paralysis, melancholia, etc., in chronic interstitial nephritis, in chlorosis, gout, and chronic rheumatism.

Total Phosphates.—Add to the urine magnesia mixture (see Appendix) and ammonia. The total phosphates are precipitated, and can be compared with a corresponding precipitate from a normal urine.

Earthy Phosphates—Approximate Estimation.—Place 2 inches of urine in a 6-inch test-tube, add a few drops of sodium hydroxide and heat to boiling. Set aside for 15 minutes to allow the precipitate to settle. If the phosphates be normal the precipitate will occupy about $\frac{1}{2}$ inch at the bottom of the tube; if high, 1 inch or more; if low, less than $\frac{1}{4}$ inch.

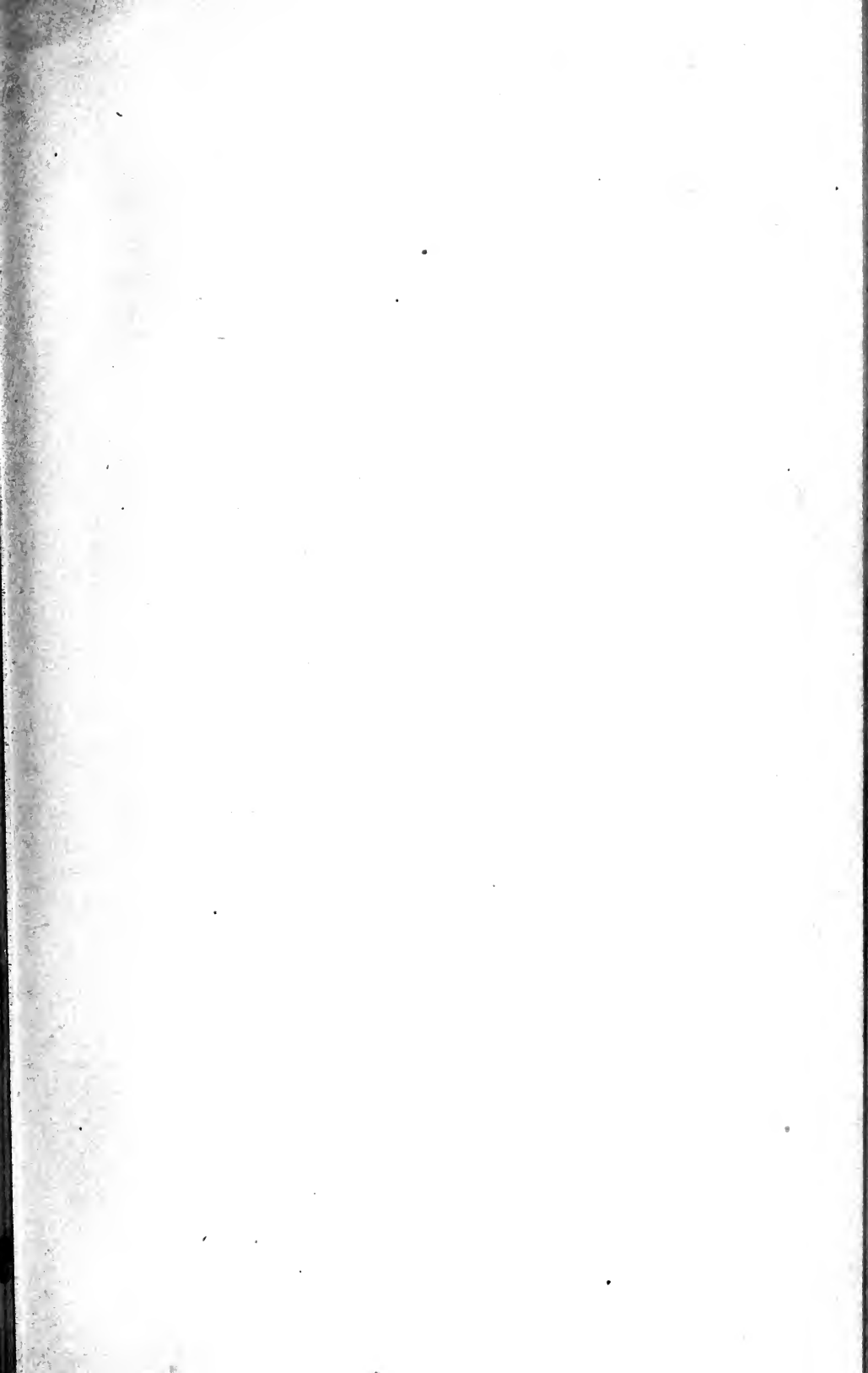
Alkaline Phosphates.—Approximate Estimation.—Add a little ammonium hydroxide to the urine, filter off the precipitated earthy phosphates, and to the filtrate add $\frac{1}{3}$ volume of magnesia mixture. A semi-opaque cloudiness on shaking indicates normal phosphates; a creamy appearance, increased phosphates; a slight cloudiness, decreased phosphates.

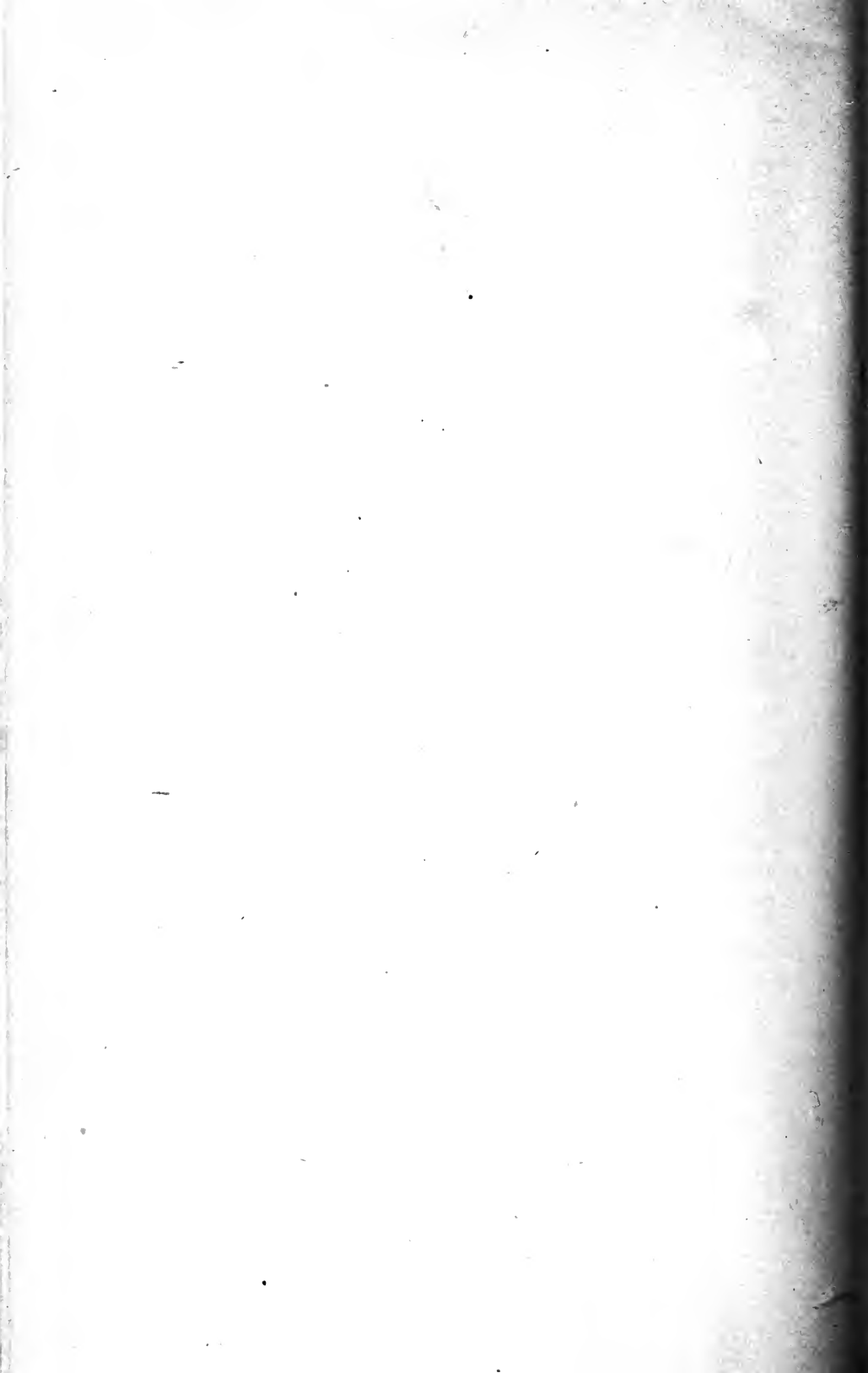
Accurate Determination of Total Phosphates.—Solutions.—Standard Uranium Nitrate:—Dissolve 35.5 grammes of uranium nitrate in a mixture of 25 c.c. strong acetic acid with 800 c.c. of water. Dilute with water to 1000 c.c. Each c.c. of this solution is equivalent to 0.005 gramme of phosphoric anhydride, P_2O_5 .

Acid Solution of Sodium Acetate:—Dissolve 10 grammes of sodium acetate in 90 c.c. of water and add 10 c.c. of strong acetic acid.

Potassium Ferrocyanide:—One gramme dissolved in 120 c.c. of water.

Method.—To 50 c.c. of urine add about 10 c.c. of the sodium acetate solution and warm the mixture to 80° C. Maintain at this temperature, and, from a burette, add the standard uranium nitrate, testing from time to time until a drop of the mixture develops a brown color when touched with a drop of potassium ferrocyanide. The number of c.c. of uranium nitrate used, mul-





multiplied by 0.005, gives the weight in grammes of phosphoric anhydride in the 50 c.c. of urine.

INDICAN.

Indican, or, properly, potassium indoxyl-sulphate, $C_8H_6-NKSO_4$, is derived from the indole, C_8H_7N , of the intestine. Normally present in small amount, it becomes greatly increased in certain intestinal disorders from absorption of decomposition products. It is increased generally in cancer of the liver, in certain suppurative diseases, by intestinal obstruction, by peritonitis, and by administration of many aromatic drugs, creosote, turpentine, etc.

To 5 c.c. concentrated hydrochloric acid add 20–30 drops of urine and warm, but do not boil, the mixture. With normal urine the resulting color will be yellow or a very pale violet, while with increased indican a darker violet or blue will be obtained. Add 2 drops of nitric acid and warm gently. There may be a slight increase in color at first, but this will be followed by the disappearance of the blue tint—more or less rapidly, according as to whether little or much indican be present.

BILE.

Bile constituents may occasionally appear in the urine of healthy persons, particularly during the heat of summer, but as a rule their presence is characteristic of the condition known as jaundice. Bile pigments and bile acids may both be present, but the clinical examination is practically limited to the former. The urine is generally yellowish-brown to green, sometimes almost black, and yields a characteristic yellow froth on shaking. It must be remembered, however, that certain drugs may produce a similar appearance.

TESTS FOR BILE PIGMENTS. *Marechal's Test.*—Float a few drops of tincture of iodine on the surface of the urine in a test-tube. In presence of bile pigments, a green coloration appears below the red iodine layer.

Gmelin's Test.—The urine is floated over yellow nitric acid in a test-tube. A succession of colors, green, blue, violet and red, will appear at the contact of the two liquids.

In Rosenbach's modification of this test the urine is filtered through a thick paper. A drop of yellow nitric acid applied to the

inside of the dried filter will produce a yellow spot surrounded by yellowish-red, violet, blue and green rings.

Huppert's Test.—The urine is treated with lime water, or with a solution of calcium chloride followed by ammonium carbonate; the precipitate is filtered off, thoroughly washed, and then transferred to a test-tube. A little acetic acid is now added, then chloroform. On shaking, the acetic acid will be colored green, while the chloroform will show a yellow or a green tint according to the relative amounts of bilirubin and biliverdin present.

TEST FOR BILE ACIDS. *Pettenkofer's Test.*—Evaporate about 200 c.c. of urine to dryness, extract the residue with absolute alcohol, filter, evaporate the alcoholic filtrate, and dissolve the second residue in a little water. Add a few drops of a concentrated solution of cane sugar, and a drop of sulphuric acid, then warm the mixture in a capsule. A purple or cherry-red color indicates the presence of bile acids.

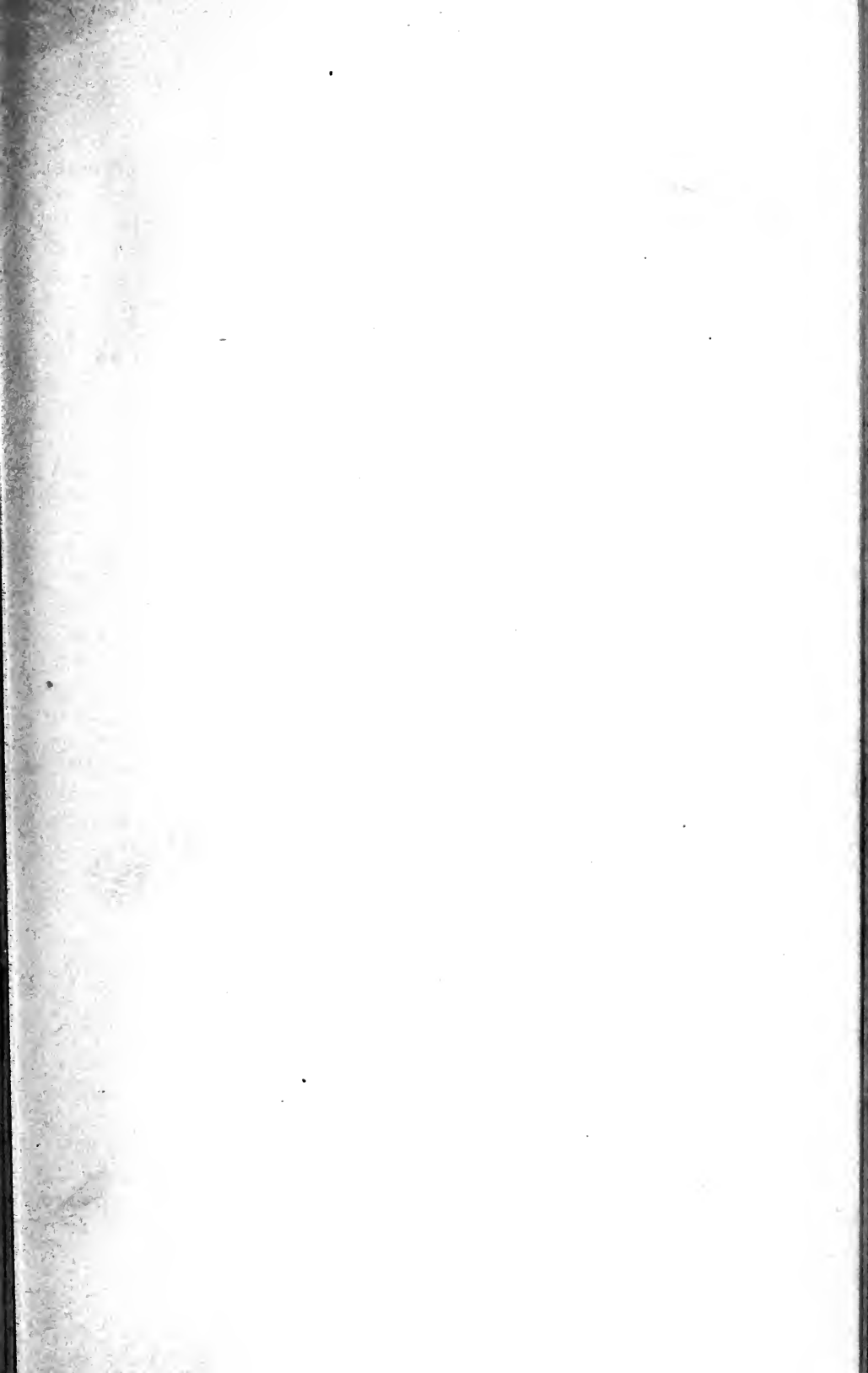
Instead of evaporating the alcoholic filtrate, the bile acids may be precipitated from that solution by an excess of ether, the precipitate separated, and dissolved in water. The water solution in either case will probably need to be decolorized by animal charcoal, before applying the color test.

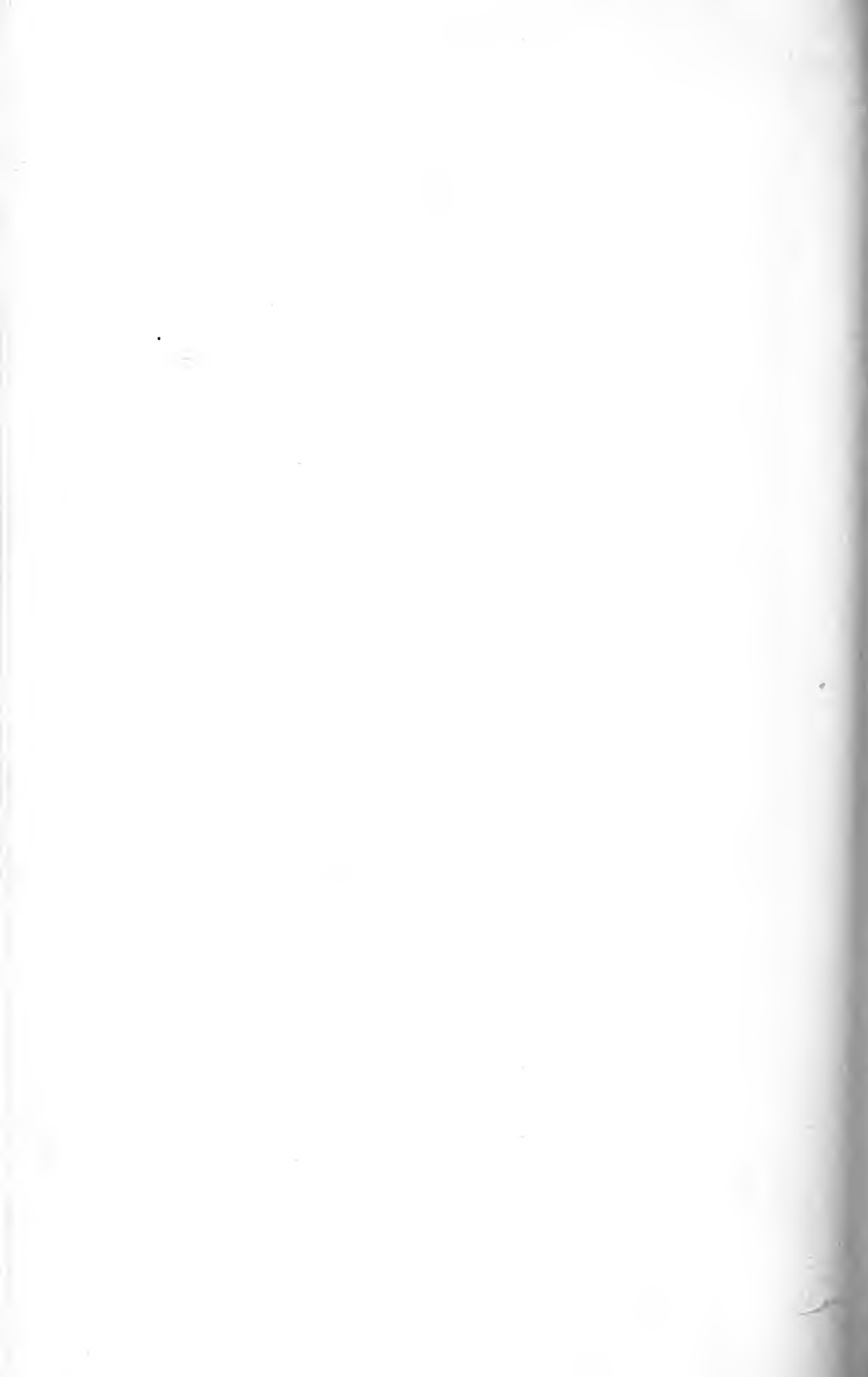
The test may be *clinically modified* as follows: To the urine, which must be albumin-free, add a little sugar syrup and then dip into the mixture a strip of filter paper. Dry the paper and touch it with a drop of sulphuric acid. Bile acids being present, a purple spot *may* be obtained.

For other modifications of the bile tests, see Index.

BLOOD.

Blood in the urine may be derived from the kidneys, in cancer, acute nephritis, after powerful diuretics, etc.; from the bladder, in diphtheritic and acute cystitis, calculi, carcinoma, congestion, etc.; from structural disease of the prostate, and from mechanical injury. When uniformly mixed with the urine the blood is probably from the kidneys, though possibly from the prostate; when stringy or in clots, it is more likely to be from the bladder or urethra. Unless in considerable amount, its recognition is best effected by microscopic examination of the sediment, or by spectrum analysis. As regards the microscopic examination, however, it is to be remembered that blood pigment may be present when





blood corpuscles are entirely absent. When the amount of blood is large the urine will be dark-red or brown, often "smoky" in appearance, and the precipitate of earthy phosphates with sodium hydroxide (*Heller's Test for blood*) will be reddish instead of white. Should the urine be alkaline and the phosphates already precipitated, add an equal volume of normal acid urine and a few drops of barium chloride before boiling with sodium hydroxide. Hæmoglobin may be detected by the *Guaiacum Test*.—To the urine in a test-tube add 3–4 drops of a freshly prepared tincture of guaiacum and mix by shaking. Float on the surface of a mixture a little etherial solution of hydrogen dioxide ("ozonic ether") and let it stand without shaking. In presence of hæmoglobin (and of some other substances) a blue color will develop in the etherial layer at the contact between the two liquids.

Lecanau's Test may be used for the detection of hæmatin. The urine is acidulated with acetic acid and boiled. The brown coagulum is separated, washed with water, and shaken with alcohol which has been acidulated with sulphuric acid. The reddish-brown solution is filtered and the filtrate examined spectroscopically. A part of the same filtrate may be evaporated to dryness and the residue tested for iron.

Hæmin Test.—Place a few drops of the urine on a glass slide and add a drop or so of glacial acetic acid. Heat cautiously until bubbles appear. On cooling there will separate out dark brown triclinic plates and prisms of "hæmin," the hydrochloride of hæmatin.

See also under Blood, p. 97.

OTHER ABNORMAL INGREDIENTS.

Serum-Globulin.—This resembles serum-albumin and generally accompanies it in the urine. It is insoluble in water and may be detected by dropping the urine slowly into a beaker of clear water, each drop as it falls producing a slight cloud. Serum-globulin responds to most of the albumin tests. To separate globulins and albumins, saturate the urine with magnesium sulphate; the globulins are precipitated and can be filtered off. Test the filtrate for albumin.

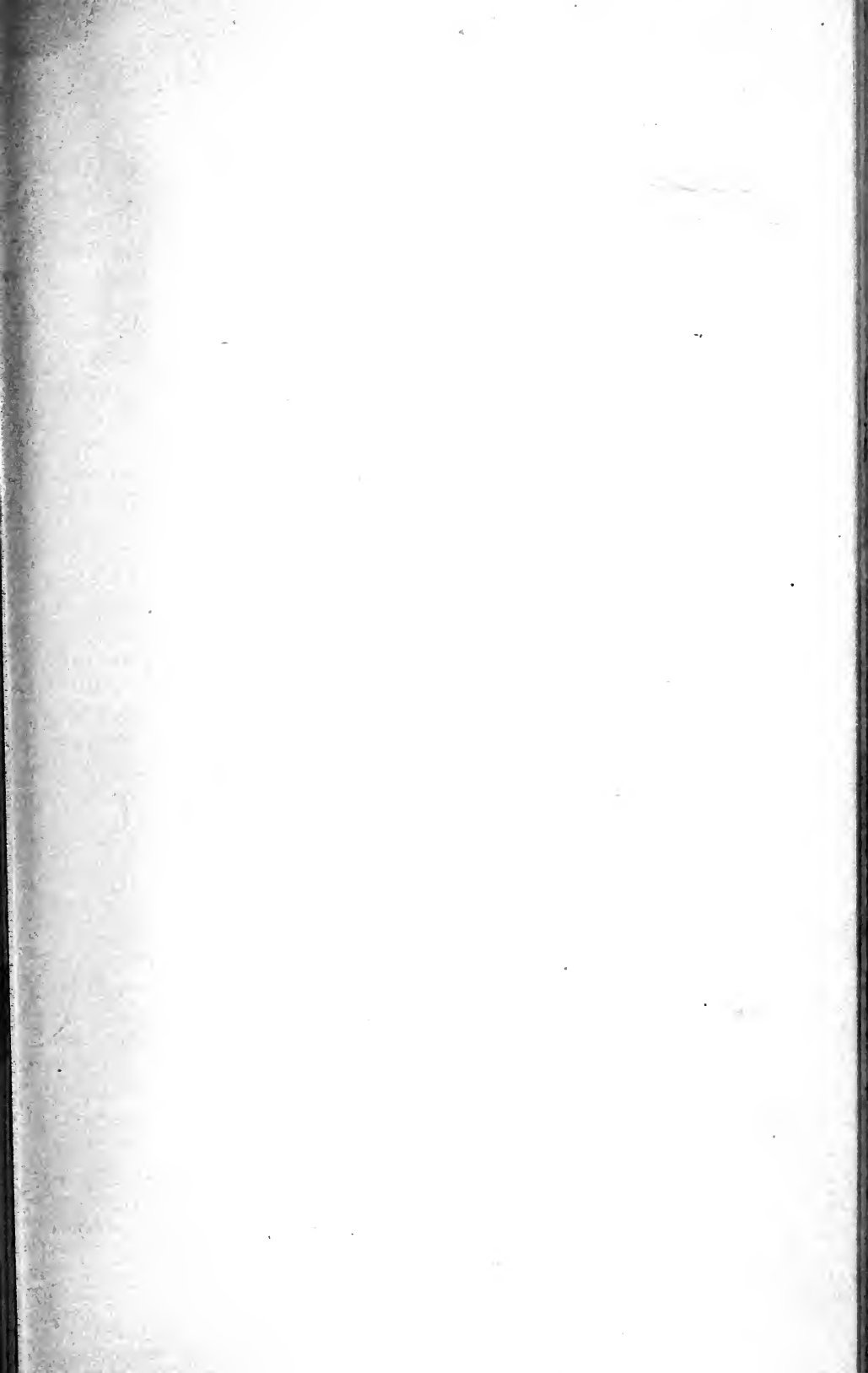
Albumose.—Tested for in presence of other proteids, as follows: Saturate the urine with sodium chloride, acidify with acetic acid, boil, and filter while hot. The albumose separates from the fil-

trate on cooling; dissolve in water and apply the nitric acid test. Albumose precipitated by nitric acid, dissolves on heating, and is reprecipitated on cooling.

Peptones.—Peptones may appear in the urine in acute rheumatism, in suppurative diseases, in cancer of the liver and intestines, in croupous pneumonia, typhoid, scarlet fever, small-pox, and in tuberculosis. Deutero-albumose is, however, often mistaken for peptone. In presence of other proteids, acidify with acetic acid, add ammonium sulphate to saturation, filter and examine the filtrate for peptones by the xantho-proteic test and by precipitation with picric acid. Show the absence of other proteids by the nitric acid contact test.

Acetone, $(\text{CH}_3)_2\text{CO}$.—Normally present in minute amount, is increased in febrile conditions, in the later stages of diabetes mellitus, and, frequently, after profound narcosis. It may be tested for in the urine directly, or after distillation of the urine with phosphoric acid. *Legal's Test.*—To 5 c.c. of the urine (or to 25 c.c. of the distillate) add sufficient sodium hydroxide to give a decided alkaline reaction, and then add a few drops of a fresh aqueous solution of sodium nitroprusside. The mixture assumes a ruby-red color. Acidify the solution with glacial acetic acid, a purple-red color indicates the presence of acetone. *Chautard's Test.*—A drop of an aqueous solution of magenta, previously decolorized by sulphurous acid, added to the distillate, develops a rich violet color.

Acetylacetic Acid, $\text{C}_2\text{H}_3\text{OCH}_2\text{CO}_2\text{H}$, commonly called *Diacetic Acid*, or its ethyl ether compound, is related to acetone in its occurrence, and is possibly an intermediate step in the formation of acetone. Its appearance in the urine of a diabetic is to be considered of grave import. Diacetic acid may be tested for as follows: To the *fresh* urine add a few drops of a neutral solution of ferric chloride. Filter off any precipitated phosphate, and to the filtrate add two drops more of the iron salt. A Bordeaux-red color being produced, diacetic acid may be present. Repeat the test, using a boiled portion of the urine; little or no color will now be developed if the color of the first test were due to the acid. As a further test a portion of the urine is acidulated with sulphuric acid and extracted with ether. Apply the iron test to the ethereal extract. If the color produced fade in 24–48 hours, it is probably due to diacetic acid; if it does not fade, it may be due to hydroxybutyric acid.



Hydroxybutyric acid, $C_4H_8O_3$, is closely related to acetone and diacetic acid and often occurs with them in the urine. It is found in the later stage of diabetes, in cachexia, also sometimes in scarlet fever, measles, etc. It responds to the ferric chloride test for diacetic acid.

Glycuronic Acid, $C_6H_{10}O_7$.—Occurs in normal urine in traces, but is much increased by ingestion of chloral, nitrobenzole, camphor, morphine, etc., and particularly after a profound chloroform narcosis. It is of importance because of its resemblance to glucose, responding to several of the principal glucose tests. It does not, however, respond to the fermentation test with yeast, and unless present in large amount gives no reaction with phenylhydrazin, provided this test be performed exactly as described on page 109. With insufficient heating of the mixture crystals are obtained, melting at $150^{\circ} C$.

In common with *pentose*, glycuronic acid gives the following test: Decolorize the urine with charcoal and add 0.5 c.c. to 5-6 c.c. of a saturated solution of phloroglucin in strong hydrochloric acid. Upon warming a purple-red color is developed.

Pus.—Pus in the urine may be from renal abscess, from inflammation or cancer of the bladder, from suppuration in the prostate or urethra, etc. When the pus originates in the bladder the urine is generally alkaline; when from the kidneys, the urine is generally acid. Pus is best recognized microscopically, but, if in considerable amount, the following tests may be applied: The whitish sediment always present in a urine carrying pus is not dissolved by heat. It is insoluble in dilute acids, and—*Donné's Test*—with sodium hydroxide it forms a semi-gelatinous, ropy mass. Hydrogen dioxide added to pus causes a rapid effervescence.

Fat.—May be due to an excess of fatty food, or it may occur in fatty degeneration of the liver, in phosphorus poisoning, etc., occasionally in diabetes mellitus and in Bright's disease. When the fat is present in considerable amount the urine will be more or less milky in appearance and, on standing, the fat globules will rise to the surface. The fat may be extracted from such a sample by agitation with ether. When present in small amount the fat globules, or fatty casts, will be recognized in the microscopic examination.

In *chyluria* all of the chyle constituents, fat, proteids, etc., are present. *Cholesterol* has been found in chyluria, and, also, in fatty

degeneration of the liver and, sometimes, in diabetes, and in jaundice.

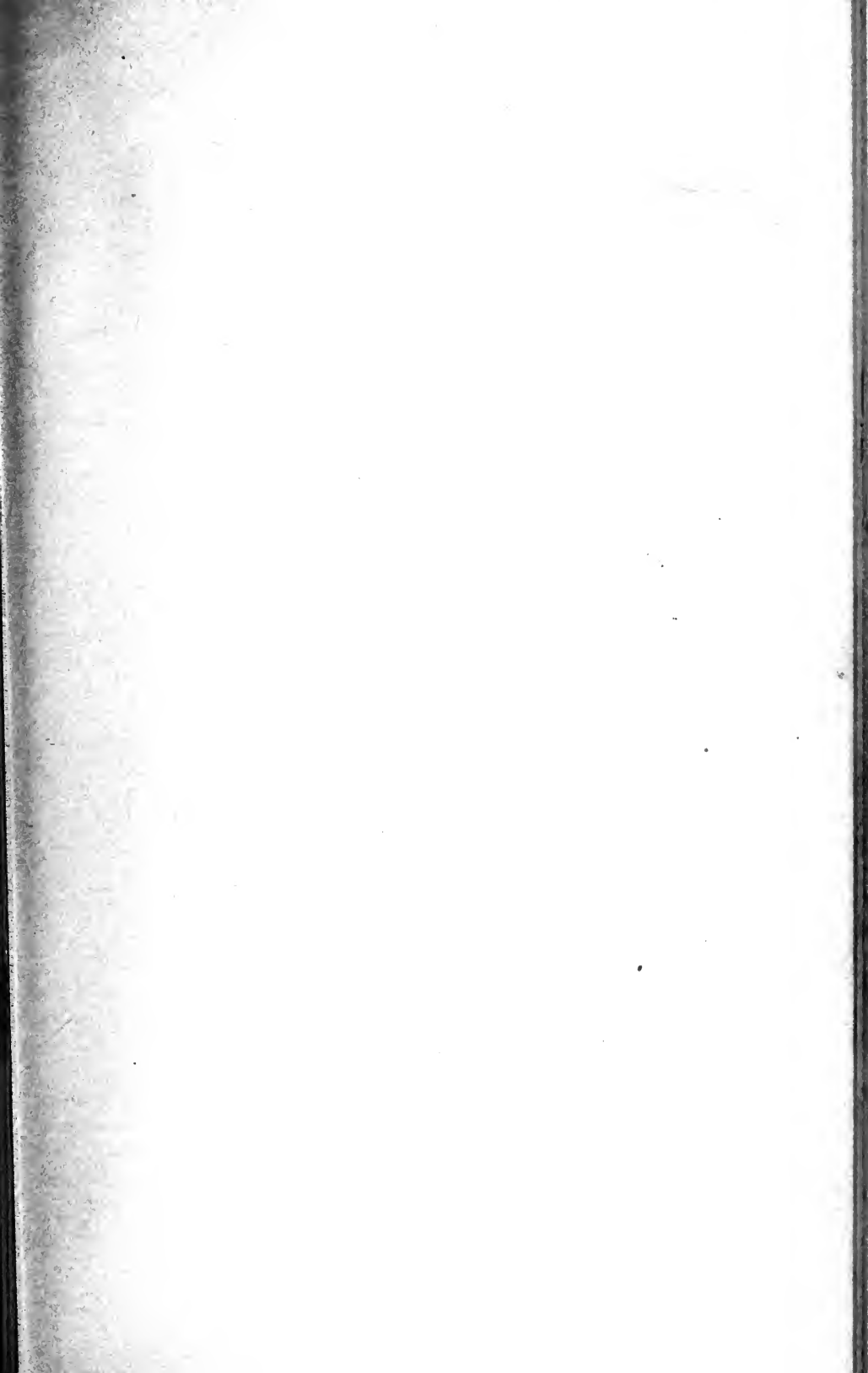
Drugs, Alkaloids, etc.—In irritant poisoning the urine often contains albumin and blood. In phenol poisoning, and after ingestion of phenol derivatives, the urine is dark colored and may become black on exposure to the air. Indican seems to be increased in the urine by the ingestion of oil of bitter almonds, turpentine, and creosote. After the ingestion of balsams a test may be obtained with nitric acid resembling that given by albumin. Santonin, chrysophanic acid, rhubarb, and senna, give an orange-yellow color. Asparagus, turpentine, cubeb, and valerian, all impart characteristic odors. Salicylates are excreted as salicylic and salicyluric acids. Glycuronic acid is increased by chloral, nitrobenzole, camphor, and morphine, and after chloroform narcosis. The ingestion of potassium iodide causes the urine to give a greenish-blue coloration in the guaiacum test for blood. Quinine and antipyrine darken the urine. Quinine, atropine, strychnine, morphine, and other alkaloids may be excreted in part unchanged. Sulphonal may produce a dark red urine, the color being due to hæmatoporphyrin.

Iodides and iodoform are tested for by adding a little dilute starch paste and then a few drops of yellow nitric acid; a blue color indicates presence of iodine.

Ehrlich's "Diazo-Reaction."—Two solutions are prepared, one a saturated solution of sulphanilic acid in 50 c.c. of hydrochloric acid, diluted to 1000 c.c. with water, the other a 0.5 per cent. solution of sodium nitrite.

In applying the test one part of the nitrite solution is added to 50 parts of the sulphanilic acid solution, and then one volume of this mixture is added slowly to an equal volume of urine. Ammonium hydroxide is added in slight excess and the tube is well shaken. A carmine-red color appearing in the foam as well as in the body of the liquid, constitutes the diazo-reaction. Normal urine shows an orange coloration.

This reaction, it is claimed, is given by the urine of typhoid fever patients from the 4th to the 7th day, continuing, possibly, to the 22nd day. It is given, also, by the urine in acute febrile diseases, in pneumonia always, generally in pleurisy, sometimes in malaria, in measles, in erysipelas, peritonitis, miliary tuberculosis, pyæmia, and in scarlet fever, and, rarely, in rachitis, and



in diabetes mellitus. In phthisis pulmonalis a persistent reaction is of grave significance. In miliary tuberculosis the reaction is not obtained until the third week, and, therefore, it may serve to differentiate this disease from typhoid fever.

URINARY SEDIMENTS.

Urinary sediments may be divided into two groups, organized or anatomical, unorganized or chemical. The anatomical sediments include mucus and pus cells, blood corpuscles, epithelium, casts, spermatozoa, fungi, etc. The chemical sediments vary with the reaction of the urine, *acid urine* containing amorphous and semi-crystalline urates of sodium and potassium, crystalline uric acid, calcium oxalate, and, rarely, crystalline calcium acid phosphate, cystin, leucin and tyrosin; while *alkaline urine* may contain amorphous phosphate and carbonate of calcium, crystalline ammonium urate, ammonium magnesium phosphate, phosphates of calcium and magnesium, and calcium oxalate.

The sediment is separated from the urine by deposition, or, better, by use of the centrifuge. When the examination is to be delayed it is necessary to guard against fermentative changes, and for this purpose camphor, salicylate of sodium, thymol, formaldehyde, or chloral hydrate may be added.

CHEMICAL EXAMINATION OF THE SEDIMENT.

Warmed with water: Soluble: Urates (and hippurates, normal calcium urate only slightly, leucin, tyrosin and xanthine slightly).

Insoluble: Phosphates, oxalates, uric acid (cystin, cholesterol and, possibly, leucin, tyrosin and xanthine).

Add acetic acid: Soluble: Phosphates and carbonates, the latter with effervescence. (Leucin and tyrosin, and xanthine slightly).

Insoluble: Oxalates, uric acid (hippuric acid, cystin, cholesterol, sulphates and, possibly, tyrosin).

Add hydrochloric acid: Soluble: Oxalates, phosphates, and carbonates (effervescence). (Urates and hippurates dissolve but decompose with separation of uric and hippuric acids; leucin, tyrosin, cystin dissolve; sulphates partially dissolve.) *Insoluble:* Uric acid (also hippuric acid and cholesterol, the latter soluble in ether).

Add sodium hydroxide: Soluble: Uric acid (leucin, tyrosin, cystin, xanthine and bilirubin crystals). *Insoluble:* Oxalates, phosphates,

carbonates (sulphates and cholesterol). (Earthy phosphates are precipitated from solution.)

As regards the effects of the above reagents on the possible organic contents: *heat* may coagulate albumin; *acetic acid* may precipitate mucin and may dissolve casts, etc.; *hydrochloric acid* may precipitate albumin and may destroy casts, etc.; sodium hydroxide may dissolve mucus to a clear solution, and may convert pus into a thick, viscous mass. Micro-organisms are dissolved by sodium hydroxide and are also evidenced by a milkiness in the urine, not removable by ordinary filtration.

ANATOMICAL SEDIMENTS.

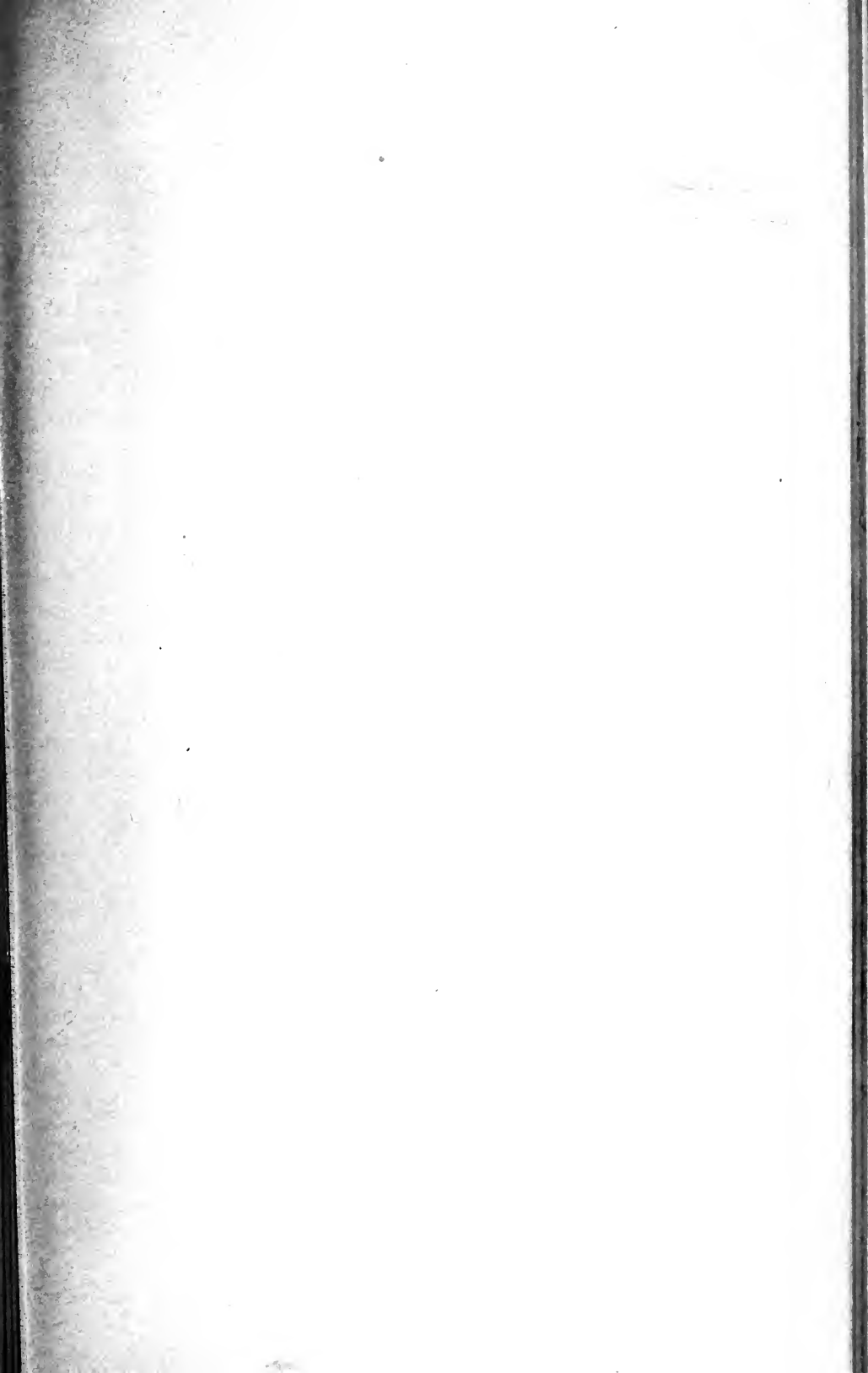
Mucus Cells.—Often present in normal urine. Round or oval globules with faintly marked margins, averaging about 0.01 mm. in diameter, but sometimes swelling to twice that size, generally with but a single nucleus. (See also, p. 104.)

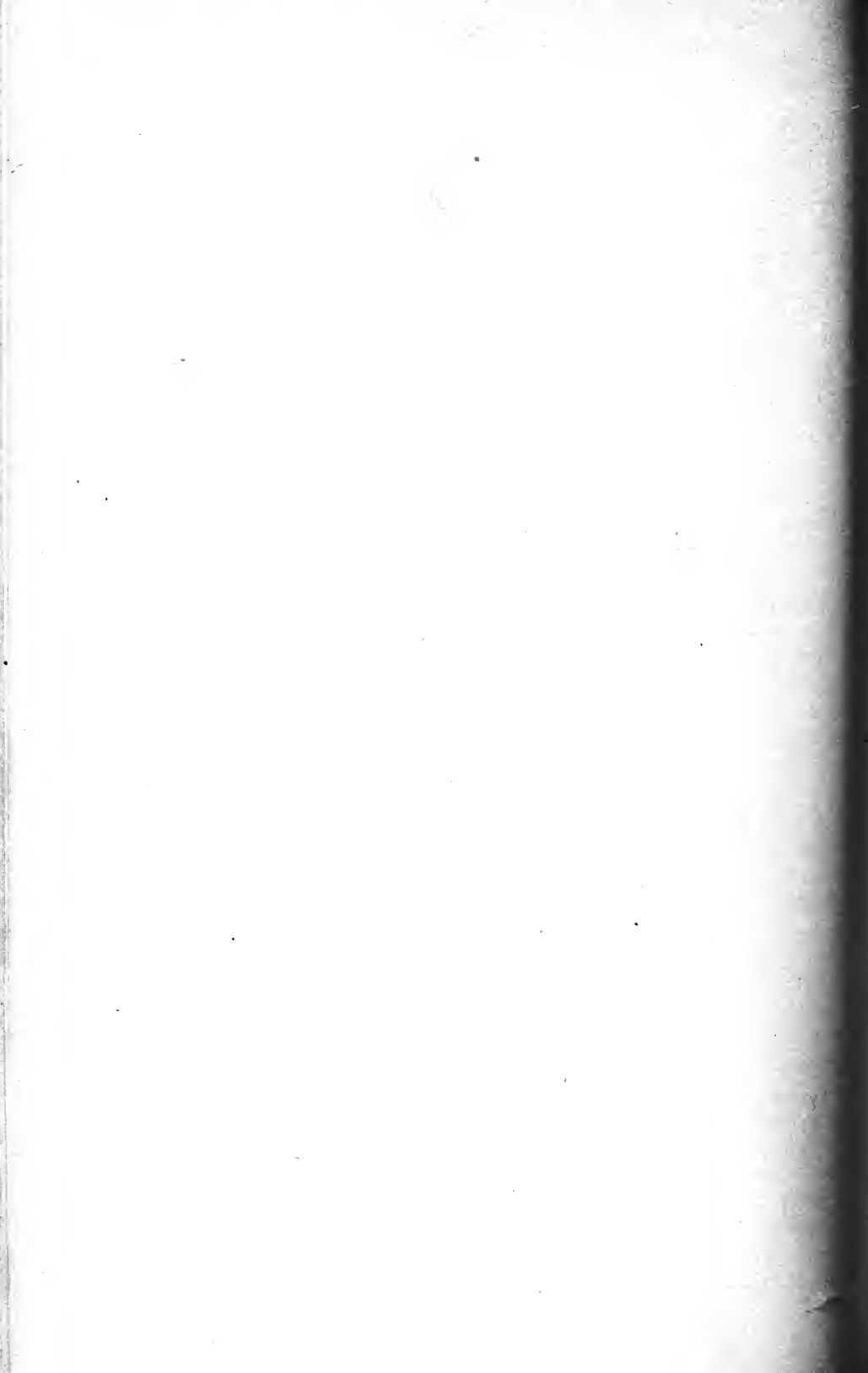
Pus Cells.—From suppuration in the urinary tract. Similar to mucus cells in appearance, but distinguished by being generally multinuclear, the indistinct nuclei being rendered more prominent by addition of acetic acid. The pus cells are distinguished from white blood corpuscles by their somewhat larger size, their granular appearance and their more irregular outlines. The addition of alkalis converts pus into a gelatinous mass. Urine carrying pus yields albumin by chemical tests. (See also, p. 121.)

Blood Corpuscles.—Recognized as more or less yellow biconcave discs with smooth or crenated margins, generally without nuclei. In dilute urine the corpuscle is often swollen, and occasionally is biconvex in form. In concentrated urine shrunken and crenated corpuscles are common. (See also, p. 118.)

Epithelium.—Occurs in rounded, cylindrical, polygonal, or granular cells, often nucleated. These may originate in the bladder, ureters, pelvis of the kidney, kidney, urethra, or vagina. The large, flat "squamous" cells from the vagina and bladder are common in the urine of women. Renal epithelial cells are rounded or polygonal, small, and often with a large nucleus. Certain of the smaller round cells may resemble pus, but their single nucleus and greater size will easily distinguish them. Epithelium is much increased by catarrh in the urinary organs.

Casts.—Moulds of the uriniferous tubules of the kidney, pointing to a diseased condition of that organ, inflammation, congestion,





etc. Classed, according to appearance, as hyaline and waxy casts, epithelial casts, blood, fatty, and granular casts. They are, in general, cylindrical in shape, with rounded ends, often nearly transparent and difficult to identify. They are best detected after staining with iodine or with magenta, and by use of concentrated light. They are quickly destroyed by the fermentation of the urine. Casts are found in acute and chronic nephritis, in jaundice, etc. Hyaline casts may occur in all forms of albuminuria, in fever urine, and in many chronic disorders. As the disease or inflammation progresses, granular, epithelial and blood casts become more numerous. Fatty casts indicate a fatty degeneration. Blood casts indicate a renal hemorrhage. The presence of casts together with pus and blood generally suggests the renal origin of the latter.

Fungi, Bacteria, etc.—Absent from normal urine when passed, but often developing rapidly on exposure to the air. Yeast fungi are often abundant in diabetic urine. The micrococcus ureæ, derived from the atmosphere, multiplies rapidly in urine, and is the chief factor in the ammoniacal fermentation.

Bacteria may be examined for as follows: A little of the sediment is spread on a cover-glass, dried, and passed quickly through a Bunsen flame, to fix the layer. Stain for fifteen minutes in warm carbol-fuchsin (fuchsin, 1 part, absolute alcohol, 10 parts, and 5 per cent. phenol, 100 parts), and then dip for several seconds in 5 per cent. sulphuric acid. Wash with water, and stain with methylene blue (concentrated alcoholic solution of methylene blue 30 parts, 0.01 per cent. potassium hydroxide 100 parts). Wash again with water, dry, and mount in balsam. Tubercle bacilli appear red, all others will be stained blue.

For *Gonococci* spread the sediment on a cover-glass and fix by heat as described above. Then cover the deposit with a few drops of ordinary methylene blue or violet solution. Wash in water, place on a slide and examine at once in water or in glycerol, or, dry and mount in balsam. The more or less kidney-shaped gonococci are found generally in pairs united by their flattened surfaces. The presence of the gonococci within the pus cells is particularly significant.

Spermatozoa are often present, and may occasionally prove to be of medico-legal interest. Their characteristic form is easily recognizable under a high power.

CHEMICAL SEDIMENTS.

Uric Acid.—Common in acute fevers, uric acid diathesis, gravel, etc. Found in acid urine in red or brownish-yellow crystals. The crystals, which are described as whetstone, envelope, spear and fan-shaped, are often gathered together in bunches or in rosettes. They are insoluble in acids, but are dissolved by alkalis, and, slowly, by heat. The murexid test (p. 113) may be applied.

Urates.—In acid urine, associated with uric acid, we find sodium and potassium acid urates. In alkaline urine we find crystalline or amorphous ammonium urate. The urates are generally amorphous, or in a state of semi-crystallization in the form of balls studded with spicules. Crystalline forms are somewhat more common in alkaline than in acid urine. The murexid test (p. 113) may be applied.

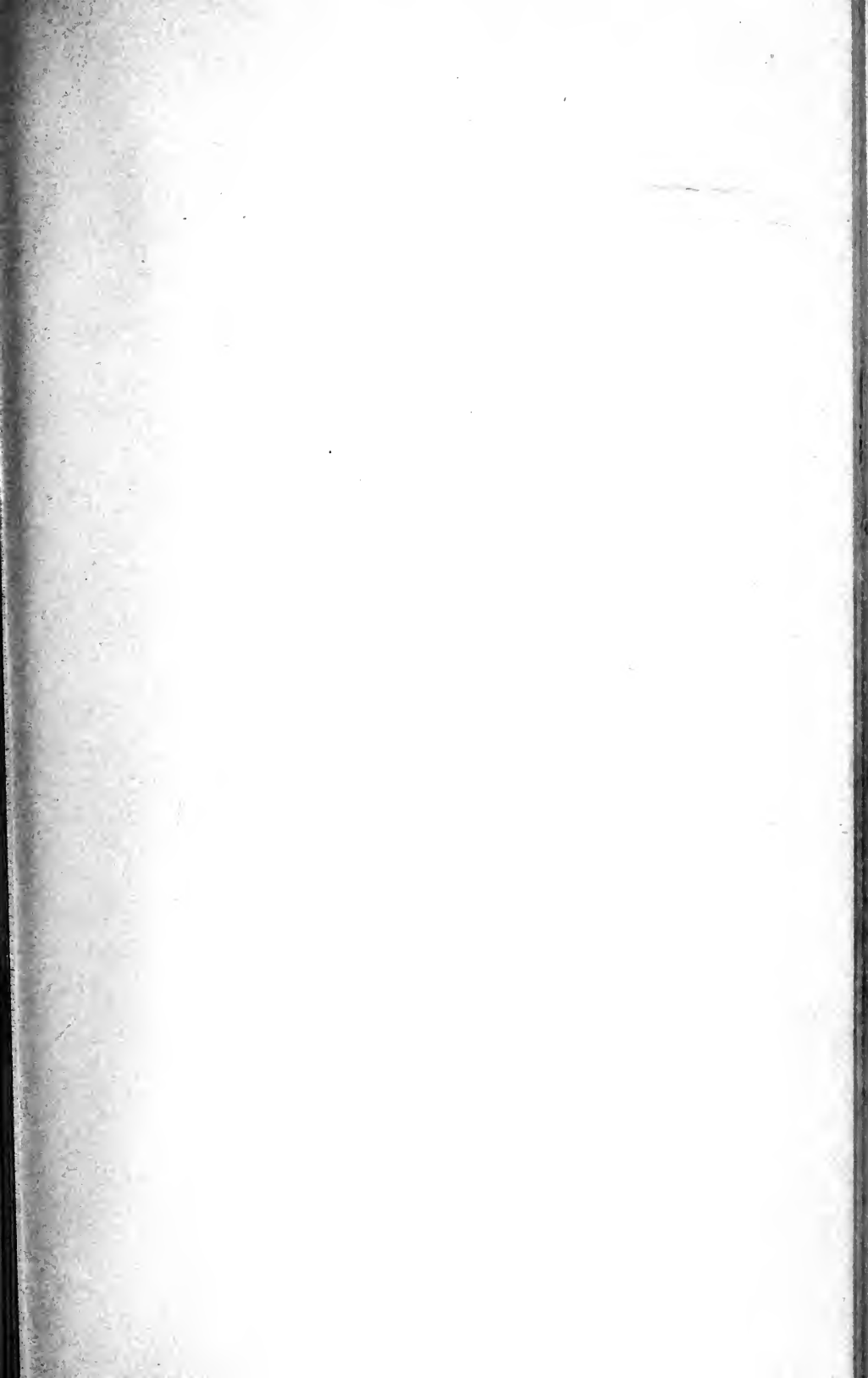
Oxalates.—Calcium oxalate occurs in the urine in small octahedra or in envelope and dumb-bell forms. Its presence is not especially significant, though it may point to mal-assimilation, and is often associated with an increase in uric acid.

Phosphates.—Crystalline di-calcic phosphate may occur (rare) in acid urine. In alkaline urine we may have amorphous phosphates of calcium and magnesium, crystalline tri-magnesium phosphate (rare), crystalline di-calcic phosphate in rosettes, spherules, or dumb-bells, ammonium magnesium phosphate, "triple phosphate," in large beveled-edged prisms, or, occasionally in stellate feathery forms. When present in freshly voided urine, the triple phosphate indicates decomposition of the urine in the bladder. The presence of other crystalline phosphates and of amorphous phosphates is not particularly significant.

Carbonates.—Rare as a sediment. Amorphous calcium carbonate may occur in alkaline urines, occasionally in imperfect dumb-bell forms, but generally as rounded or oval granules with dark contours.

Leucin.—A rare sediment, occasionally appearing in white shiny lamellæ, generally, however, in groups of yellowish striated spherules, somewhat like those of sodium urate, but distinguished from the latter by not dissolving on application of heat. They are distinguished from oil-drops by their insolubility in ether.

Tyrosin.—A rare sediment, occurring with leucin in acute atrophy of the liver, in small-pox and in typhus. It is usually



found in the form of yellowish-green globules, but when pure occurs in fine needle-like crystals radiating from a center.

Cystin.—A rare sediment, found in colorless six-sided transparent plates, often in overlapping masses. The crystals are soluble in hydrochloric acid and in ammonia, but are insoluble in water. A trace of sodium nitro-prusside added to an alkaline solution of cystin develops a violet color. Boiled with a drop of lead acetate cystin causes the separation of black lead sulphide. Cystin is of interest chiefly because of its tendency to formation of calculi.

Other rare sediments are, calcium sulphate, hippuric acid and hippurates, cholesterol, xanthine, fat globules, and bilirubin crystals. For the behavior of these and the other sediments with chemical reagents, see page 123.

URINARY CALCULI.

Calculi may consist of uric acid and urates, of calcium oxalate, ammonium oxalate, and more rarely of phosphates, carbonates, cystin, xanthine, etc. As a rule, each calculus is built up of two or more of the above substances arranged in concentric layers around a central nucleus. These layers may often be separated, and in the analysis should be examined separately.

Uric Acid and Urates form hard calculi, generally smooth, often reddish or yellowish-brown in color, and of variable size. Pure *Phosphatic Calculi* are of rare occurrence, though we frequently find phosphates deposited around a uric acid nucleus. The *Fusible Calculus* consists of a mixture of calcium, magnesium, and ammonium phosphates. It is readily fusible when heated, giving off vapor of water and ammonia. It resembles chalk in appearance and consistency. *Calcium Oxalate* is frequently met with, forming calculi often of considerable size, brown or olive in color, and with a rugged surface (*mulberry calculi*). When small and hard, the term *hemp-seed calculus* is applied. The rare *Cystin Calculi* are more or less transparent and waxy in appearance, though crystalline in structure. They are commonly tinted yellow, changing to green on exposure. *Xanthine Calculi* are very rare. They are described as yellowish-brown in color, often with scattered white spots. Occasionally altered blood clots will form concretionary masses known as *Fibrinous Calculi*.

The following scheme will serve as an aid in the recognition of the chief varieties of calculi:

Powder the calculus and heat a small portion of the powder on platinum foil in the Bunsen flame.

A. If it chars, burns, and leaves but little residue, it probably consists of either *uric acid*, *urates*, *cystin*, *xanthine*, or *fibrin*. Test a portion of the powder with boiling water; if soluble, we have *urates*; if insoluble, *uric acid*. Confirm in either case by the murexid test.

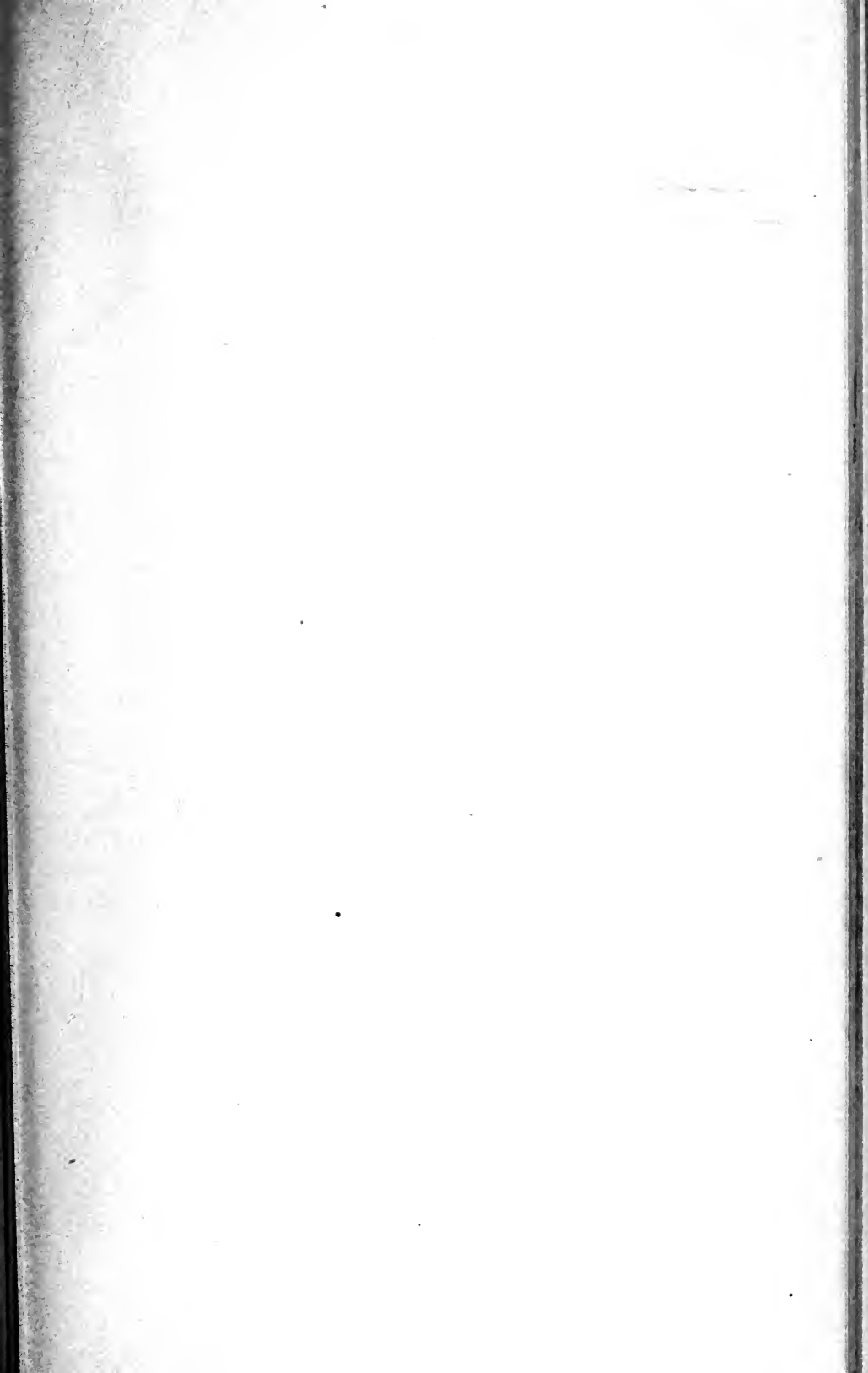
Treat another portion of the powder with hydrochloric acid, and warm; a residue may be *uric acid*; cystin and xanthine go into solution. *Cystin* gives a brown color with the murexid test and is soluble in ammonium hydroxide. The ammonia solution on evaporation yields the characteristic hexagonal crystals. For other tests see p. 127. *Xanthine* gives a yellow color with the murexid test, but if potassium hydroxide be used instead of ammonia, it turns red, and, on heating, reddish-violet. *Fibrinous calculi* will be completely burned when heated, giving off the characteristic odor of burning feathers.

B. Should the powder, when heated, char but slightly and leave a considerable residue, or possibly undergo no change at all, we may have *phosphates*, *oxalates* or *carbonates* of calcium and magnesium.

A fresh portion of the powder is treated with dilute hydrochloric acid; if soluble with effervescence, *carbonates* are present; if soluble without effervescence, we have phosphates or oxalates. A residue will probably consist of uric acid. Filter, render alkaline with ammonia, boil, acidify with acetic acid, and again filter. A white pulverulent residue is *calcium oxalate*, which, if dried and heated on platinum, is converted into calcium carbonate, soluble in hydrochloric acid with effervescence.

To the filtrate from the calcium oxalate add ammonium hydroxide; a white precipitate indicates calcium or magnesium *phosphate*. To demonstrate the presence of phosphate, calcium, and magnesium, separately, to a portion of the above filtrate from the calcium oxalate add neutral ferric chloride—a precipitate = *phosphate*. To the rest of the filtrate add ammonium oxalate. Filter off the precipitated *calcium oxalate*, and to the filtrate add a little sodium phosphate and ammonium hydroxide. If *magnesium* be present it is slowly precipitated in the form of ammonium magnesium phosphate.

C. Should the powder when heated melt and give off water





vapor with fumes of ammonia, the calculus consists of a mixture of calcium, magnesium, and ammonium phosphates. (The Fusible Calculus.)

THE SWEAT.

THE sweat or perspiratory fluid generally contains in suspension, epithelial cells and fat globules, but, when filtered, it is a clear colorless liquid with salty taste and characteristic odor. The reaction is frequently acid, possibly from presence of fatty acids from the sebum, but profuse sweat is generally neutral or alkaline. The specific gravity is about 1.005 and the total solids about 1.5 per cent. In normal sweat we find neutral fats, volatile fatty acids, cholesterol, traces of proteid, creatinin, urea, aromatic oxyacids, etherial sulphates, sodium and potassium chlorides, sulphates, and phosphates. Ammonium carbonate is generally present as a result of urea decomposition; albumin is increased in the acid sweat of acute rheumatism; dextrose appears in diabetes; urates, and oxalates, in gout; urea is increased in uraemia; lactic acid appears in puerperal fever; bile pigment in jaundice. Drugs and ingested poisons frequently appear unchanged in the sweat and may there be detected.

THE SALIVA.

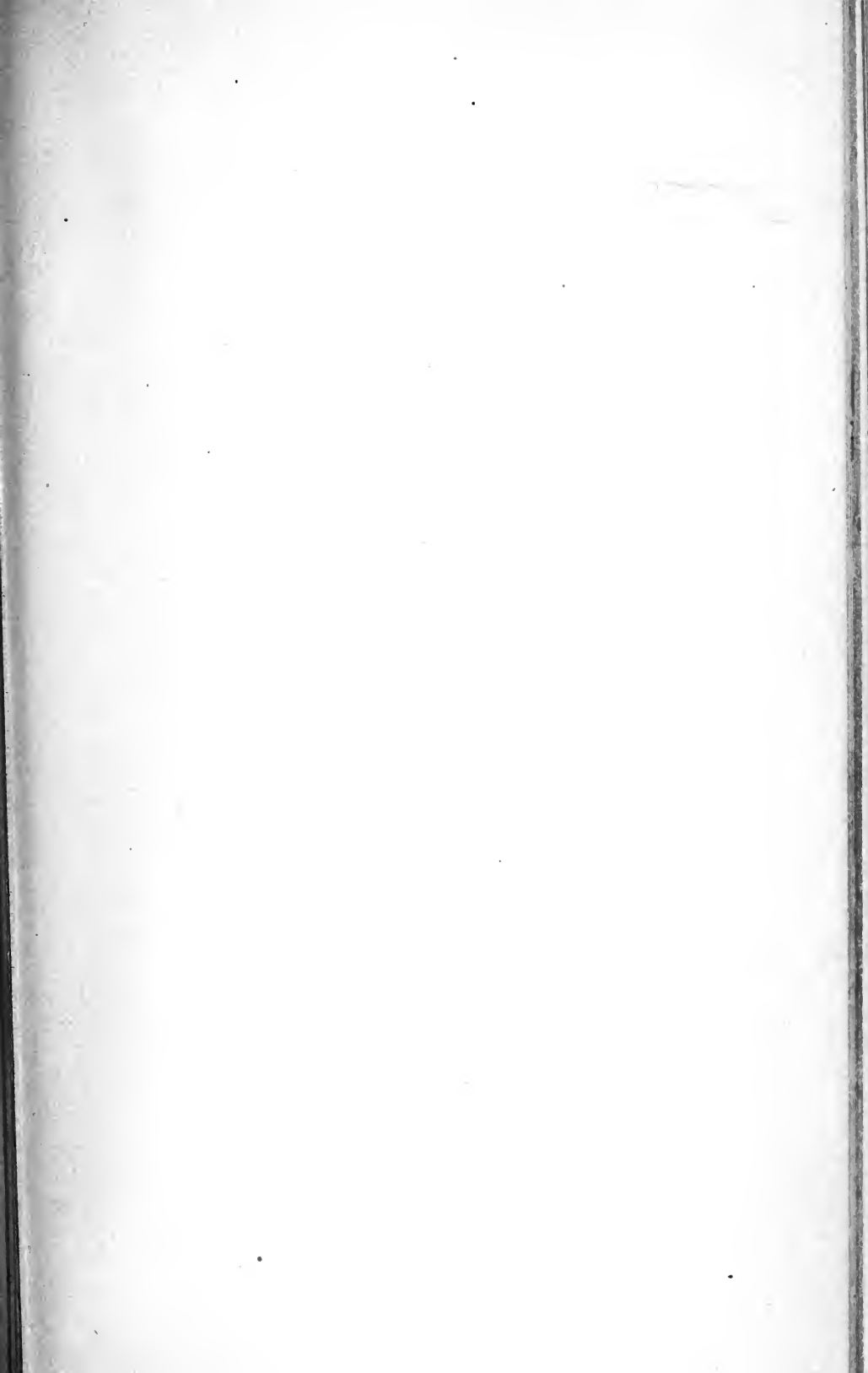
THE saliva is the mixed secretion of the parotid, submaxillary, sublingual, and buccal glands. It is colorless, clear, or faintly opalescent, usually alkaline in reaction, and froths easily. It varies in specific gravity between 1002 and 1008, and contains from 0.5 to 1.0 per cent. of solid matter, the latter consisting of albumin, mucin, ptyalin, and mineral salts. In suspension the saliva contains epithelial cells, "salivary corpuscles," and lumps of mucus. The mineral matter includes chlorides, bicarbonates, phosphates, and sulphates of sodium, potassium and calcium, with traces of other substances. On exposure to the air the carbonate of calcium is precipitated and the saliva becomes clouded.

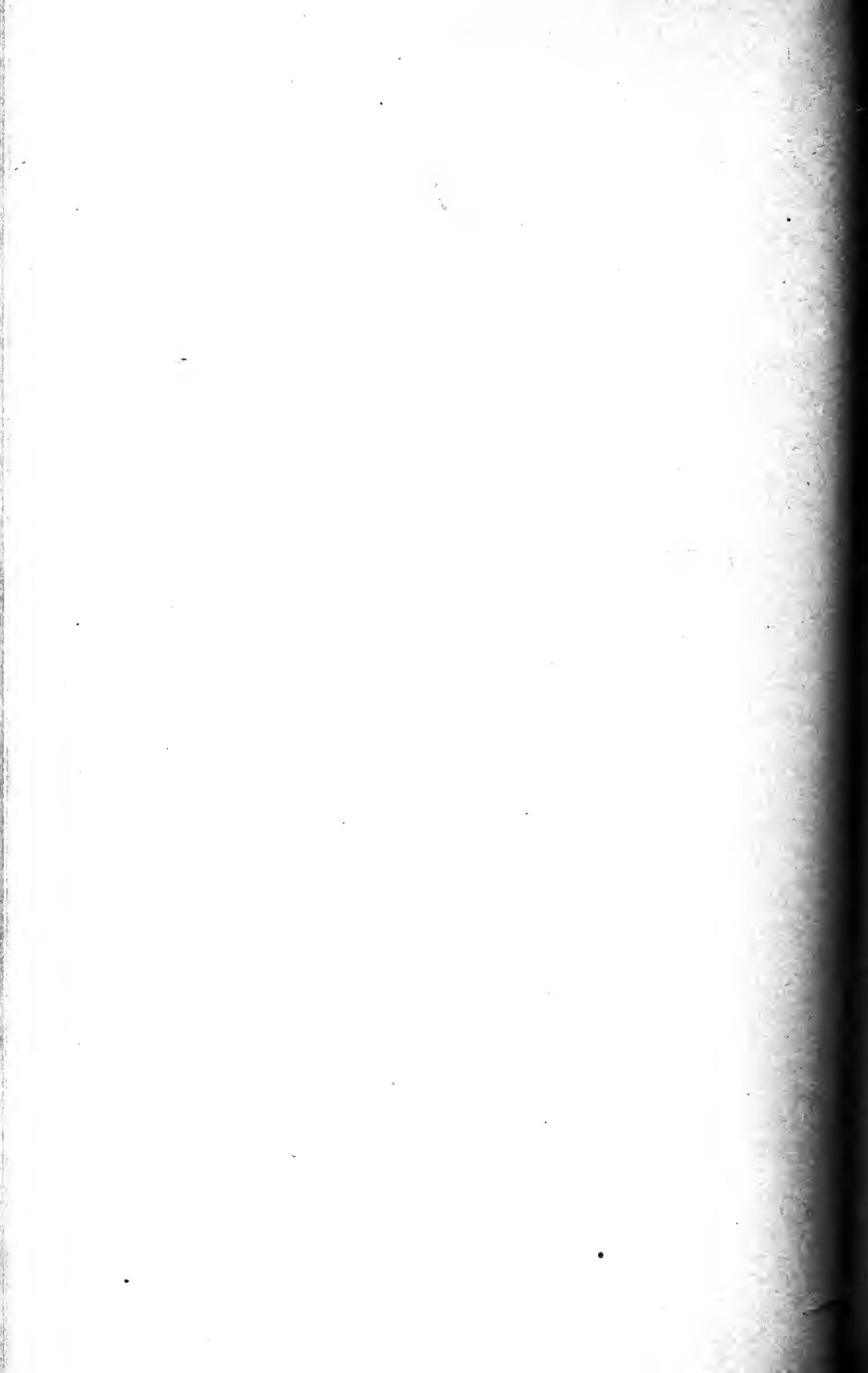
The parotid saliva is watery, free from mucin, and is rich in ptyalin. The submaxillary saliva contains more mucin than the mixed, otherwise it is similar. The sublingual is the richest in solids, the most viscid, and the most alkaline of the three.

Ptyalin, the important amylolytic enzyme of the saliva, is similar to, but not identical with, malt diastase. It converts cooked starch into maltose and dextrin, has no action on uncooked starch grains, on cellulose, or on cane sugar. It acts slowly on glycogen. The ferment acts best in a neutral medium, at a temperature of from 35° to 40° C.; it is not killed by dilute alkalies, but the action is prevented entirely by the presence of more than a trace of free acid.

To demonstrate the properties of ptyalin, test 5, on page 74 may be repeated, first as described, then with uncooked starch, with cane sugar, with cooked starch after first heating to destroy the ferment, and, finally, with cooked starch in the presence of free acid.

Saliva or sputum may be examined for bacteria by a method similar to that described on page 125, under urine. The carbol-fuchsin stain is especially suitable for the determination of tubercle bacilli.





THE GASTRIC FLUID.

THE gastric fluid is a thin, almost colorless liquid, with an acid reaction, and a specific gravity of 1001 to 1010. The following analysis is given by Schmidt:

Water	994.404
Organic Substances, chiefly Pepsin	3.195
Hydrochloric Acid	0.200
Sodium Chloride	1.465
Potassium Chloride	0.550
Other Inorganic Salts	0.186

The composition varies, however, during the digestive process and in disease. The average "total acidity" is probably between 0.10 and 0.36 per cent. The "free acid" is commonly stated as from 0.20 to 0.30 per cent., but these figures are undoubtedly high. With ordinary food the free acid will rarely exceed 0.10 per cent. The hydrochloric acid formed in the early stages of digestion combines rapidly with the proteids, and is not likely to be detected in the fluid until one-half hour after the meal. Lactic acid is commonly present in very small amount and, under certain conditions, butyric and other organic acids may appear. In fevers, in anæmia, in catarrh of the stomach, etc., pepsin and hydrochloric acid may both be considerably reduced. Hydrochloric acid may be absent in serious disease of the gastric mucous membrane, in atrophy, gastric cancer and chronic catarrh. On the other hand, it is often largely increased in gastric ulcers. In nervous dyspepsia the hydrochloric acid is normal, increased, or decreased. As a result of excessive fermentative changes, lactic and butyric acids may appear in large amount. In such a case there is always a corresponding increase in gaseous products, the stomach is distended and gaseous eructations occur. Lactic acid is increased when secretion and peristalsis are deficient; it is characteristically increased in gastric carcinoma. Among the abnormal constituents of the vomit, we may find excessive mucus, albumin, blood and

bile, while in uræmia, urea and ammonium carbonate are also often present.

The clinical examination of the gastric fluid (obtained generally by use of the stomach tube and expression about one hour after the administration of a test breakfast of a dry roll and two-thirds of a pint of water) is practically limited to the determination of the total acidity, hydrochloric acid, organic acids, and pepsin strength. The fluid is filtered and the clear filtrate tested, first qualitatively, for the acids. When lactic acid is to be tested for, an excellent test breakfast is that of Boas, a flour soup consisting of a tablespoonful of oatmeal in a litre of water.

FREE HYDROCHLORIC ACID, QUALITATIVE. *Gunzberg's Test.*—To a few drops of the filtered gastric fluid add an equal quantity of Gunzberg's reagent (see Appendix) and evaporate to dryness at a gentle heat. A bright red ring will form at the margin. It will be found convenient to use a flat porcelain dish for the test, rotating the same over a small flame and avoiding a high temperature. Organic acids do not give the reaction, but the test is said to respond to one part of hydrochloric acid in 10,000 parts of water.

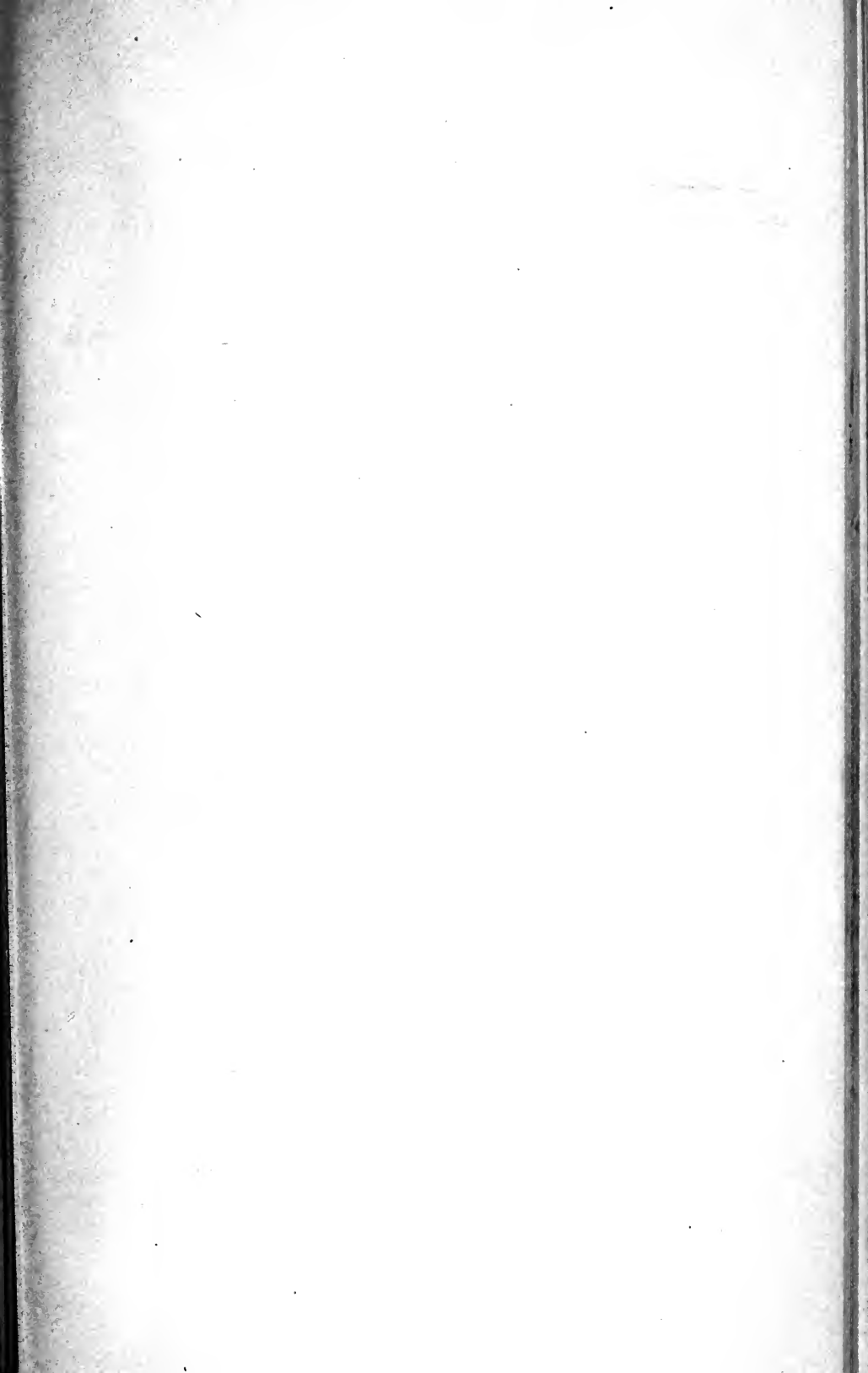
The materials for Gunzberg's reagent being expensive and sometimes difficult to obtain, *Boas' Test* is often substituted. The procedure is the same as with Gunzberg's test, and the results are practically as accurate. For Boas' reagent, see Appendix.

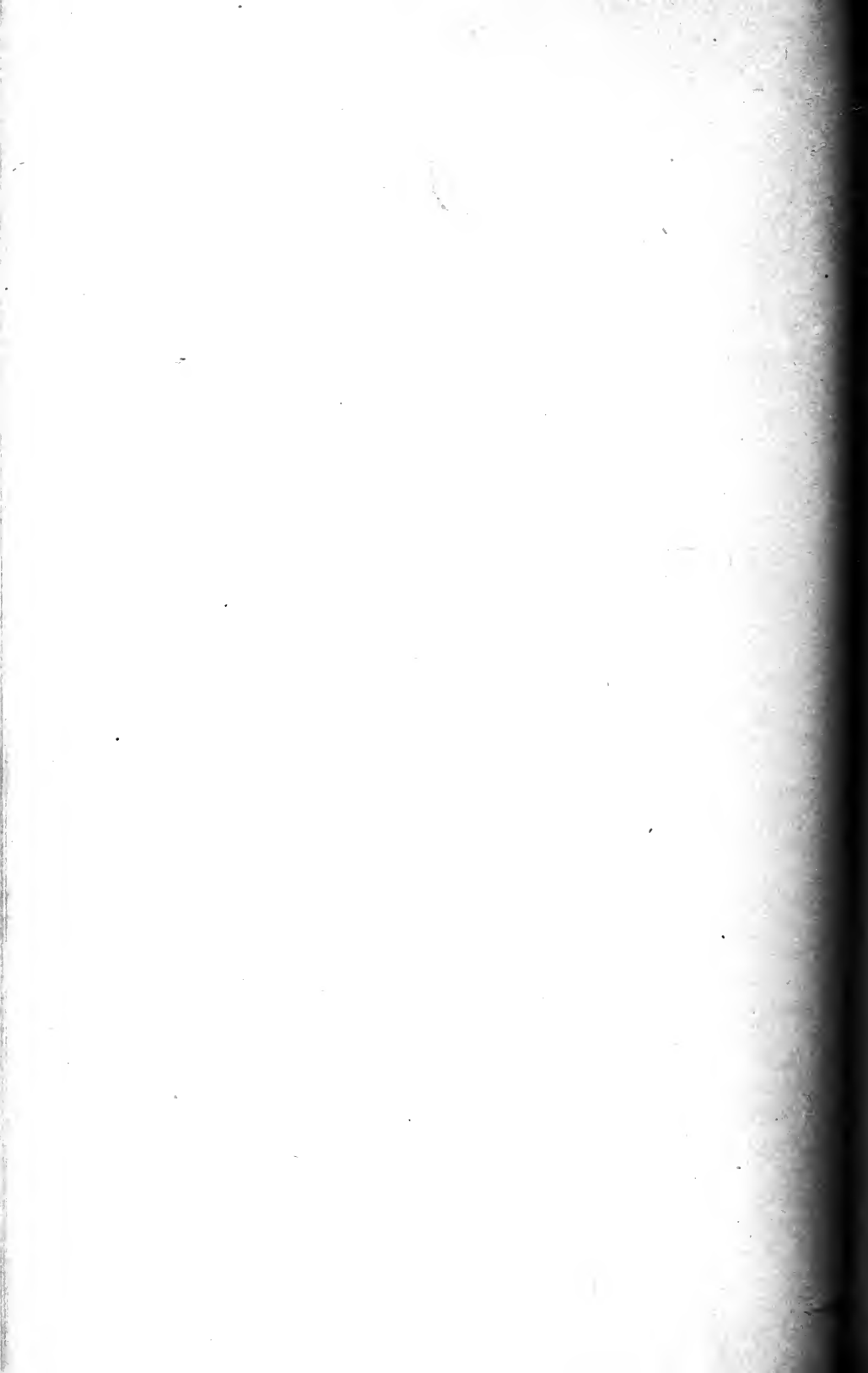
Congo-Red Test.—In presence of considerable free hydrochloric acid, a dark blue spot is obtained by touching a piece of Congo-red paper with a drop of the gastric fluid. A light blue or violet spot may be due to organic acids.

Methyl-Violet Test.—To 10 c.c. of water add a few drops of a solution of methyl-violet. Divide the test solution into 2 parts, and to one add an equal volume of filtered gastric fluid. Compare with the remainder of the test solution. A change in color, from violet to blue, indicates hydrochloric acid, but the delicacy of the test is destroyed by pepsin.

ORGANIC ACIDS, QUALITATIVE. *Uffelmann's Test for Lactic Acid.*—To Uffelmann's reagent (see Appendix) add a little of the filtered gastric fluid. The amethyst blue of the reagent is changed to a canary yellow by lactic acid (1–10,000). Hydrochloric acid may decolorize the reagent, and butyric acid turns it reddish-brown.

Other substances may interfere with the direct test, and it is therefore well to first extract the gastric fluid filtrate with ether,





evaporate off the ether, dissolve the residue in a small amount of water and then add to the reagent.

TOTAL ACIDITY, QUANTITATIVE.—Dilute 10 c.c. of the filtered gastric fluid with about 40 c.c. of water, add a few drops of alcoholic phenolphthalein solution, and titrate with deci-normal potassium hydroxide until the liquid acquires a faint pink color. The number of c.c. of the deci-normal alkali used, multiplied by 0.00364, will give the weight in grammes of hydrochloric acid in the 10 c.c. of gastric fluid. From this the percentage may be calculated. For convenience the total acids are reported, as indicated above, in terms of hydrochloric acid.

The relative amounts of free acid, organic acids, and acid proteids, may be determined by titrating a second, undiluted, sample of the gastric fluid. The deci-normal alkali is added until a drop of the fluid under examination gives no reaction with Gunzberg's reagent. The number of c.c. of alkali used serves for the calculation of the free mineral acid. The addition of the deci-normal solution is continued until no reaction is obtained with Congo-red paper, and from the number of c.c. used the organic acids are estimated, being calculated in terms of hydrochloric acid. Phenolphthalein may now be added to the fluid, and the titration continued until the pink color is developed. From this last titration the acid proteids are calculated. The total deci-normal alkali used indicates the total acidity.

For the principles involved in the above test, and for the preparation of the deci-normal alkali solution, see under Volumetric Analysis, p. 57.

PEPSIN.—The determination of the pepsin is of little practical value; it is rarely absent, and the digestion tests used are subject to other factors than the pepsin strength. Coagulated egg albumin is cut in discs 1 mm. thick and 10 mm. in diameter. Two discs are placed in each of 4 test tubes, together with 10 c.c. of the filtered gastric fluid. To one of the tubes add 2 drops of concentrated hydrochloric acid and 0.3 gramme of pepsin. To the second tube add acid alone, and, to the third, add pepsin alone. A comparison of the rate of digestion in the four tubes will indicate whether there is a deficiency of pepsin, of acid, or of both, in the gastric fluid.

RATE OF ABSORPTION AND MOTOR FUNCTION OF STOMACH.—To ascertain the *rate of absorption* administer to the patient a capsule

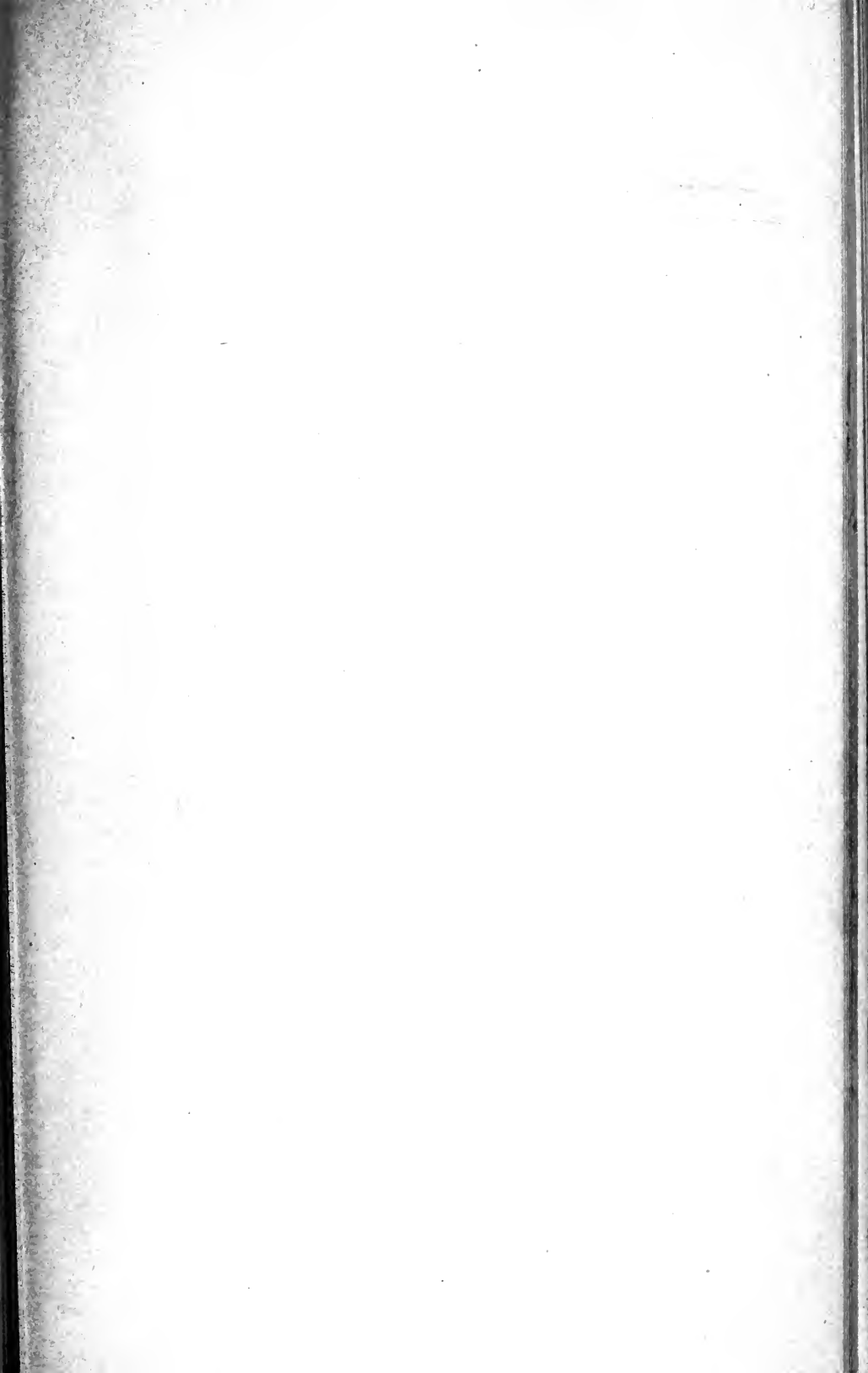
containing 0.1 gramme of potassium iodide, and after some minutes test the saliva for iodine by the following method: Dip strips of filter paper into starch paste and dry. Moisten a strip of this paper with the patient's saliva, and then, with a glass rod, touch it with a drop of nitrous acid. The presence of iodine will be shown by the appearance of a blue spot. Normally the reaction will be obtained in from 10 to 15 minutes after the administration of the capsule.

To test the *motor function* of the stomach, administer to the patient, by capsule, 0.5 to 1.0 gramme of salol (phenyl salicylate). Test the urine after one hour and after 30 hours by the following method: Dip a strip of filter paper into the urine and then touch the moist paper with one drop of a 10 per cent. neutral solution of ferric chloride. A trace of salicylic acid will develop a violet colored ring around the spot. With normal peristaltic movement the excretion of salicylic acid will begin about one hour after the administration of the salol, and will be completed within 30 hours.

ARTIFICIAL DIGESTION.—For experimental purposes the process of digestion may be imitated as described below. Thoroughly masticate, so as to mix well with saliva, a large piece of bread and place the resulting mass in a beaker. Add about 200 c.c. of water at a temperature of 40° C., and keep at this temperature, on a water-bath, for 20 minutes. Then add about 100 c.c. of artificial gastric juice (see Appendix) and maintain at a temperature of 40° C. for one hour.

The acids, organic and mineral, may be tested for as already described. To recognize the products of digestion, etc., proceed as follows: Filter and divide the filtrate into a number of parts. Show the presence of unchanged starch, by means of iodine solution. Test for maltose by Trommer's or Fehling's tests and note the violet tint due to the presence of proteids (the Biuret test). Test for albumins by boiling a portion of the clear liquid. In all probability there will be no precipitate. To the same hot liquid add dilute potassium hydroxide to neutralize the acid; a precipitate proves the presence of an acid-albumin. To another portion add nitric acid; a precipitate in the cold, soluble on heating, and reprecipitated on cooling, indicates proteoses. Saturate a portion of the liquid with ammonium sulphate, filter, and test for peptones with picric acid.

For the salivary digestion of carbohydrates, see p. 130.



THE PANCREATIC FLUID.

NORMALLY the secretion of the pancreas is a clear alkaline liquid with approximately the following percentage composition (Zawadsky): Water, 86.40; solids, 13.59, of which 13.25, including 9.20 of proteid, is organic. In other analyses the total solids have varied between 2 and 15 per cent.

The ferments of the pancreatic fluid are three in number, trypsin, a proteolytic ferment, amylopsin, an amylolytic ferment, and steapsin, a steatolytic ferment. (A fourth, a milk-curdling ferment, is mentioned. *Trypsin* resembles the pepsin of the gastric fluid, converting albumin into peptone; it differs from pepsin in that it acts best in an alkaline medium and carries the digestion further, with the production of leucin, tyrosin, aspartic acid, etc. *Amylopsin* acts upon starch, even when raw, converting it into maltose and dextrin with a trace of dextrose. It has no action on cane sugar. Glycogen is acted upon more slowly than starch. Amylopsin is comparable with, but is a more powerful ferment than, the ptyalin of the saliva. *Steapsin* splits fats into fatty acids and glycerol. The emulsifying action of the pancreatic fluid as a whole is, however, a more important factor in the preparation of fat for absorption.

An "artificial pancreatic juice" may be made by dissolving the dried pancreatic ferments in a one per cent. sodium carbonate solution. For the preparation of the ferments, a pancreas after standing for a day is minced and thoroughly extracted (several days) with glycerol. Alcohol is then added to the glycerol extract and the separated ferments are dried.

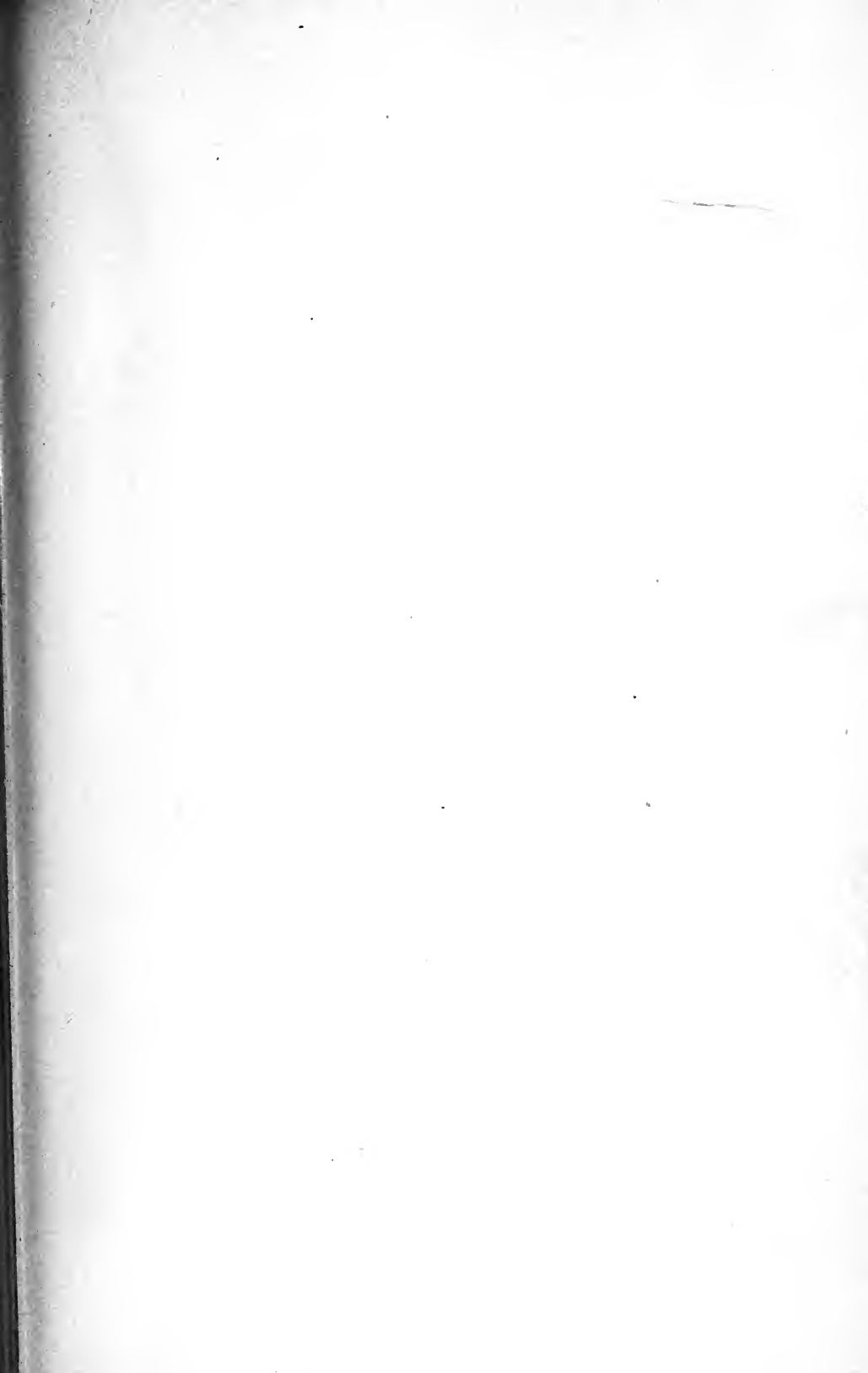
To demonstrate the digestive process place some of the alkaline ferment solution in four test tubes. To one add a small piece of fibrin. The fibrin is gradually eroded, and dissolved, alkalalbumin, proteoses, and peptones are formed and may be recognized by the tests under proteids, page 76. By long continued digestion leucin and tyrosin are also formed. To demonstrate the

leucin, acidify the solution, boil, filter, add excess of absolute alcohol to the filtrate, again filter, and evaporate the last filtrate to a small bulk. Leucin is separated from the yellow fluid and may be recognized under the microscope or by other tests (see Index). The tyrosin may be tested for as follows: Precipitate the proteid compounds with Millon's reagent, filter, and boil the filtrate. A red color indicates tyrosin.

To the second tube add starch solution, maltose and dextrin are formed. Compare with salivary digestion, page 130, and apply tests. To the third tube add cane sugar—no change. Heat the fluid in the fourth tube to 60° C. and then cool. Divide this solution and test again with fibrin and with starch. No reaction is obtained in either case.

THE INTESTINAL FLUID.

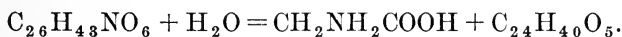
The secretion of the intestinal glands is an alkaline fluid containing an important enzyme, *Invertin*, an inverting ferment which converts disaccharids, cane sugar, maltose, lactose, etc., into the monosaccharid, dextrose. Like all alkaline fluids the secretion undoubtedly also assists in the emulsifying of fat.



THE BILE.

THE bile is a mixture of the secretions of the liver cells and of the mucous membrane of the biliary ducts and bladder. It is a golden-yellow, greenish, or brown, alkaline liquid with a specific gravity between 1010 and 1040. The lower specific gravity, with from 1.5 to 3.0 per cent. of solids, is characteristic of bile obtained from a fistula. Normally we have about 14.0 per cent. of solids made up as follows (Frerichs): Sodium glycocholate and taurocholate, 9.14; cholesterol, lecithin, and fat, 1.18; mucus and pigment, 2.98; mineral salts, 0.78.

Glycocholic acid is present in the form of the sodium salt. On decomposition with acids, alkalies, or ferments, it yields glycocin and cholalic acid:



Taurocholic acid, $\text{C}_{26}\text{H}_{45}\text{NO}_7\text{S}$, also present as the sodium salt, on similar decomposition yields taurin, $\text{C}_2\text{H}_7\text{NO}_3\text{S}$, and cholalic acid. Other acids are also present, *e. g.*, Fellic acid, $\text{C}_{23}\text{H}_{40}\text{O}_4$. The principal bile pigment is Bilirubin, $\text{C}_{16}\text{H}_{18}\text{N}_2\text{O}_3$, golden-yellow, and from this by oxidation we get Biliverdin, green, containing one more atom of oxygen in its molecule.

TEST FOR BILE ACIDS.

Pettenkofer's Test. Add to the bile concentrated sulphuric acid and warm to about 60°C . Then add a ten per cent. cane sugar solution, drop by drop, with constant stirring. A purple-red color turning to violet indicates the presence of bile acid.

The test is due to the decomposition of the bile acid, to the production of furfural by action of the sulphuric acid on the sugar, and to the combination of this with the cholalic acid. The reaction is prevented or obscured by overheating and by excess of sugar. A similar reaction may be given by certain other substances, *e. g.*, oleic acid, amyl alcohol, and morphine. *See, also,* page 118.

TESTS FOR BILE PIGMENT.

Gmelin's Test. A drop of bile is spread in a thin film on a porcelain plate and a drop of yellow nitric acid added. In the presence of bile pigment the drop of acid is surrounded by colored rings—green (biliverdin), blue (bilicyanin), and reddish-yellow (choletelin). Too much nitrous acid renders the succession of colors indistinct, and alcohol should be absent; proteids do not interfere.

Huppert's Test may be made as described on page 118 or, the moist precipitate, obtained on addition of lime water, may be placed in a test tube half filled with acidified (sulphuric acid) alcohol and the mixture boiled for some time. If pigment be present an emerald-green color is developed.

In testing for bilirubin in blood, precipitate the proteid matter with alcohol, filter, acidify the filtrate with sulphuric acid and boil; the liquid becomes green in color.

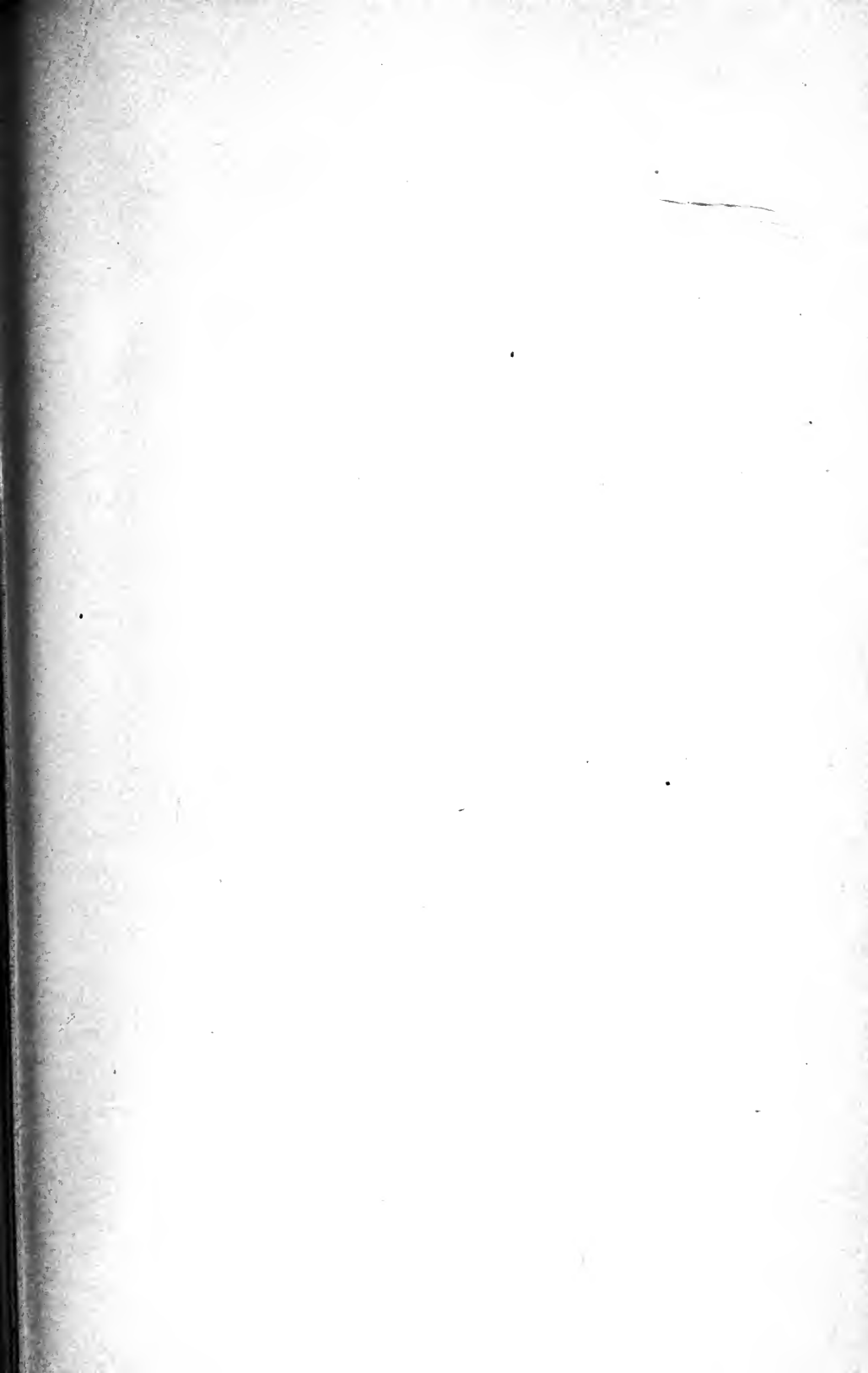
See, also, page 117.

BILIARY CONCRETIONS.

“Gall stones” may consist of calcium salts with pigment, the so-called “pigment stones,” or, more commonly, they are formed of cholesterol.

Cholesterol, $C_{27}H_{45}OH$, is found in varying amount in all the tissues of the body, especially in the brain and nerves, in semen, and in the excretions. It may be obtained in crystalline plates, insoluble in water, dilute acids or alkalies, soluble in boiling alcohol, in ether, chloroform, oils, and, slightly, in solutions of bile salts. It may be obtained from the concretion by crushing, boiling with water, and then with alcohol. On cooling the alcoholic solution cholesterol separates out. This impure product is then boiled with alcoholic potassium hydroxide, the alcohol is evaporated, the residue extracted with ether, and the ether filtered and evaporated.

Salkowski's Test. Dissolve the cholesterol in chloroform and add an equal volume of concentrated sulphuric acid. The chloroform solution is violet-red, while the acid is dark red with a greenish fluorescence. As a micro-chemical test the cholesterol crystal touched with a drop of sulphuric acid shows colored rings, first carmine-red, then violet.



MILK.

AVERAGE COMPOSITION OF MILK.

	Human Colos- trum (Tidy).	Human Milk (Leeds).	Cow's Milk (König).	Cow's Milk (Hoppe-Seyler).
Water,	84.077 p. c.	86.732 p. c.	87.17 p. c.	85 to 86 p. c.
Solids,	15.923 "	13.268 "	12.83 "	14 to 15 "
Casein, } Albumin, }	3.228 "	1.995 "	{ 3.02 " 0.53 "	3 to 4 " 0.3 to 0.5 "
Fat,	5.781 "	4.131 "	3.69 "	— to 4.0 "
Lactose,	6.513 "	6.936 "	4.88 "	4.5 to 5.0 "
Salts,	0.335 "	0.201 "	0.71 "	—

The salts consist of chlorides and phosphates, of calcium, magnesium, sodium, and potassium, with a small amount of iron and a trace of silica. There are, also, certain gases in solution: According to Pflüger, 100 volumes of milk contain 7.60 of carbonic anhydride, 0.10 of oxygen and 0.70 of nitrogen.

Frankland gives for woman's milk an average of 11.4 per cent. solids, divided as follows: Proteids, 2.7; Fat, 3.5; Lactose, 5.0; Salts, 0.2. For cow's milk he gives an average of 12.5 per cent. solids divided into: Proteids, 4.2; Fat, 3.8; Lactose, 3.8; Salts, 0.7. Rotch gives as a normal woman's milk, 12.5 per cent. of Organic solids, including, Fat, 4.0; Lactose, 7.0, and Casein, 1.5. The variations in the stated composition of woman's milk are due partially to individual peculiarities and partially to the methods of sample collection. "Fore milk" gives about 10 per cent. solids, while "Stripping" may give as high as 15 per cent. There is also a variation during the day, afternoon milk being high in solids, and the composition is further affected by age, temperament, number of pregnancies, diet, exercise, regularity of nursing, etc.

Pathological alterations may occur after the administration of certain drugs, atropine, colchicum, chloral, opium, etc., and in morbid conditions. In osteomalacia the salts are increased; in

acute fevers the amount decreases, the casein increases; in syphilis the salts increase, while both casein and fat decrease. Neurotic influences, catamenia, and starvation lower the percentage of fat and to a less degree the sugar, while the casein may be slightly increased. An over-rich milk may be due to too liberal feeding without proper exercise, the solids in such cases reaching 15-17 per cent.

The germs of infectious diseases may be recognized by physiological and microscopical tests. Cow's milk occasionally exhibits an abnormal appearance due to the presence of chromogenic bacilli, not necessarily, however, pathogenic in character. "Red" and "Blue" milks are examples of this phenomenon.

TO RECOGNIZE THE CONSTITUENTS OF MILK.

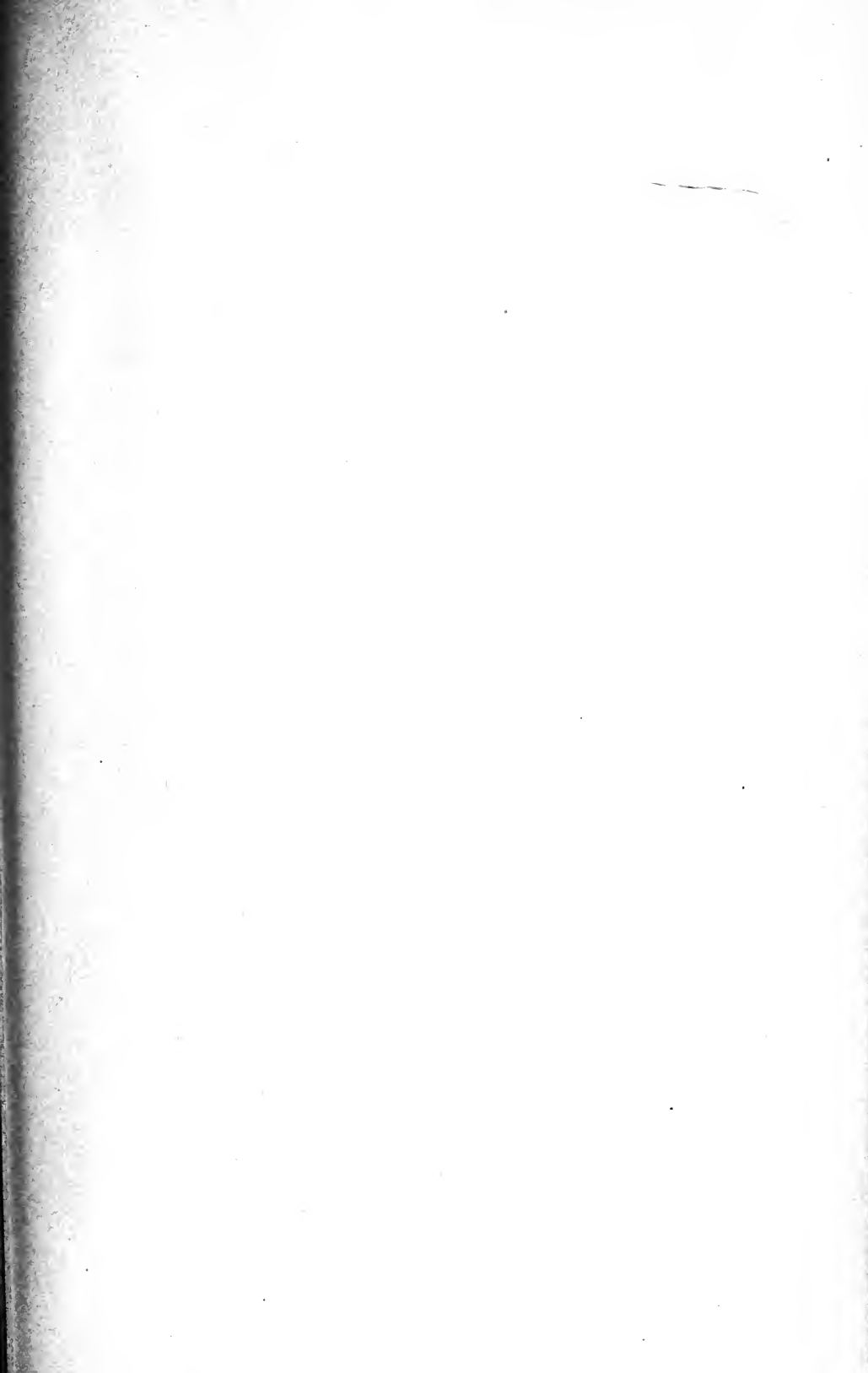
1.—Dilute the milk in a beaker with two or three volumes of water, warm, and add a few drops of acetic acid. Note the separation of the *caseinogen*. This precipitate (and also the coagulum of *casein*, formed easily by addition of rennet) contains considerable butter-fat, which may be extracted with ether after first washing with absolute alcohol. Filter off the caseinogen and reserve the filtrate, the *Whey*, for tests 2 and 3. Test the *caseinogen* as follows: (a) Apply the xantho-proteic test. (b) Apply Millon's test. (c) Warm with water and add a few drops of sodium hydroxide; the caseinogen goes into solution and may be reprecipitated by addition, to neutralization, of dilute acetic acid.

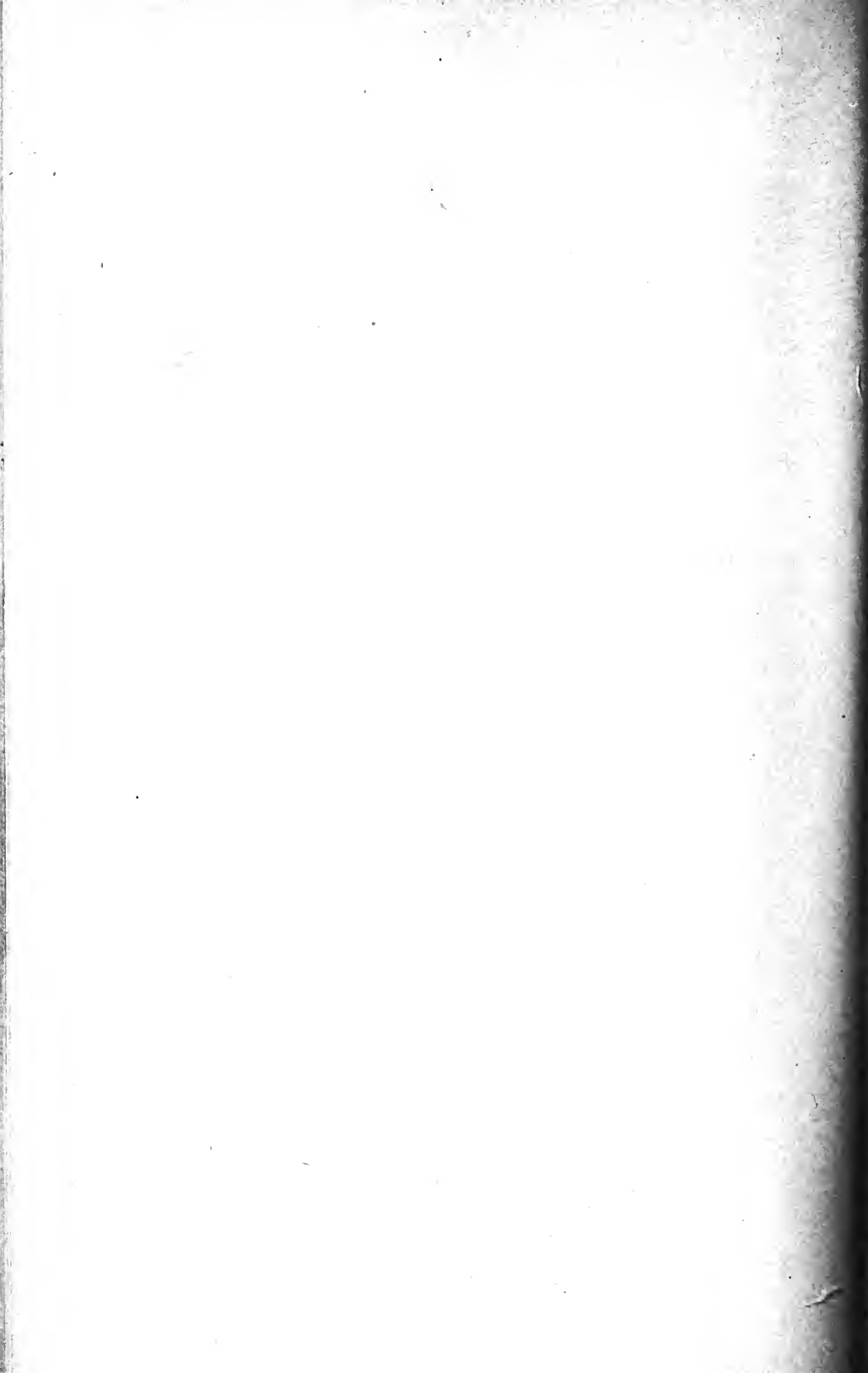
2.—Test the whey for *Lactose* as follows: (a) By Moore's Test. (b) By Trommer's Test.

3.—Test the whey for *Inorganic Constituents*. Place the whey in an evaporating dish, add a few grains of sodium or potassium nitrate, and evaporate to dryness with occasional stirring. When the mixture is near dryness heat cautiously until it ignites. Then heat strongly until a white ash remains. Let it cool, add a little water and a few drops of dilute nitric acid, warm gently, and filter. Divide the filtrate into 2 parts and test: (a) For *Phosphates*, with ammonia and magnesia mixture. (b) For *Chlorides*, with nitric acid and silver nitrate.

4.—To some cream in a test-tube, add a little sodium hydroxide and a few drops of alcohol. Warm gently and note the characteristic odor of butyric ether, indicating the presence of *Butter-Fat*.

5.—To separate the *Butter-Fat*, add to the milk one-half its volume of sodium hydroxide, and one-half of ether. Shake well





and let it stand in a warm place. The fat dissolves in the ether and floats on the top. The ethereal layer may be removed and the ether evaporated, leaving the fat in a pure state.

CLINICAL ANALYSIS OF MILK.

QUANTITY. The normal amount secreted by a healthy woman may be placed at from 700 to 1000 c.c. daily. A cow in good condition secretes 6000 to 7000 c.c. daily, or about four times its body weight in the year.

REACTION. Tested with litmus paper, human milk is normally faintly alkaline. The milk of the cow and other herbivora may be alkaline or amphoteric in reaction when first passed, but becomes acid on standing. Milk of the carnivora is acid in reaction.

SPECIFIC GRAVITY. The specific gravity of milk varies normally from 1028 to 1034. It is raised by the removal of the cream and lowered by the addition of water. When the milk has suffered both of these operations, therefore, the specific gravity may be normal. *Method.*—The specific gravity is usually taken with a hydrometer after a thorough shaking of the sample. When the temperature of the milk departs considerably from the temperature of registration of the hydrometer (usually 60° F.) a correction must be made. Sufficiently accurate results may be obtained by subtracting *one* from the hydrometer reading for each 10° below 60° F., or by adding *one* to the reading for each 10° above 60° F.

A hydrometer with specially constructed scale, known as the *lactometer*, is frequently used in the municipal control of milk. Upon this instrument the 0° mark corresponds to a specific gravity of 1000, that of pure water, while 100° corresponds to a specific gravity of 1029, the minimum acceptable specific gravity for pure milk. The scale is commonly extended to 130°, 120° corresponding to a specific gravity of 1034, the maximum for pure milk.

FAT. (Cream.)—(*a*) *By the Creamometer.*—A glass cylinder graduated into 100 parts from above downward, is filled to the zero mark with the well shaken sample. After standing for 24 hours in a cool place, the percentage of separated cream may be read directly from the graduations. This should be between 10 and 20 volumes. Comparing with the specific gravity, less than 10 volumes in a milk of specific gravity above 1033 indicates skimming. Less than 20 volumes in a milk of specific gravity below 1029, indicates the addition of water. There are, however,

several possible sources of error in this method. Cream varies in consistency and consequently in bulk, and moreover, the addition of water causes a rapid separation of the cream with an *apparent* increase in quantity.

(b) *By Feser's Lactoscope*.—This method depends upon the fact that the relative opacity of milk varies with the number of suspended fat globules. Four c.c. of milk are introduced into the instrument and water added until the black lines upon the inner cylinder are plainly visible. The volume of the mixture indicates, by graduations on the outer tube, the percentage of fat in the sample. Whole milk should show three per cent. or over, by this method.

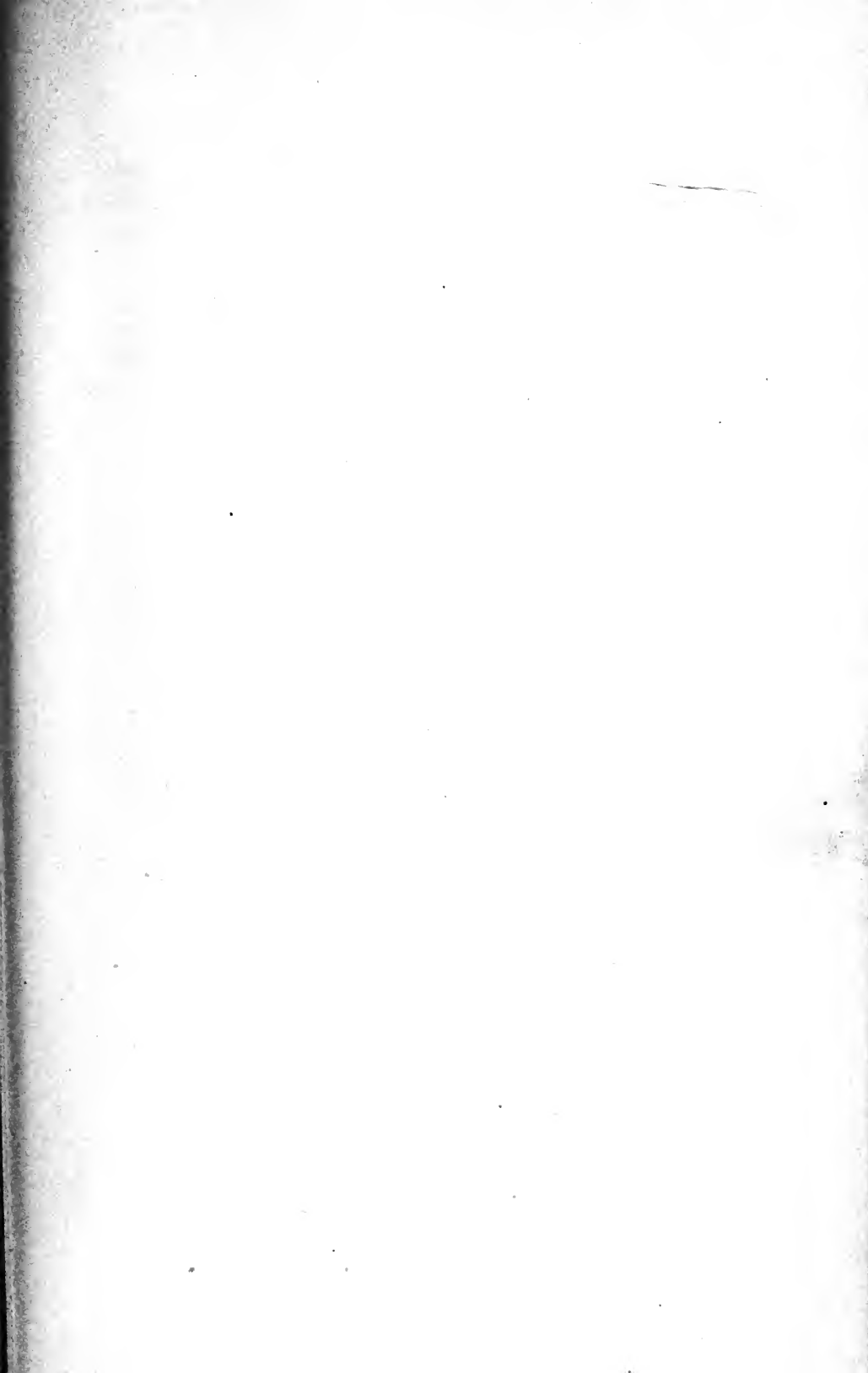
(c) *Werner-Schmid Method*.—Ten c.c. of milk are measured into a test-tube of 50 c.c. capacity and 10 c.c. strong hydrochloric acid added. The tube is stoppered and heated in a water-bath until the mixture turns a rather dark brown, when it is cooled and shaken with 30 c.c. of ether. A wash-bottle-like arrangement of cork (not rubber) and tubes is now substituted for the stopper, and the lower end of the exit tube, which is recurved, is so placed as to rest just above the line dividing acid and ether. The ether is blown out into a weighed flask and two more extractions are made, using, for each, 10 c.c. of ether, and adding the extracts to that first obtained. Distil off the ether, dry the fat at 110° C., and weigh.

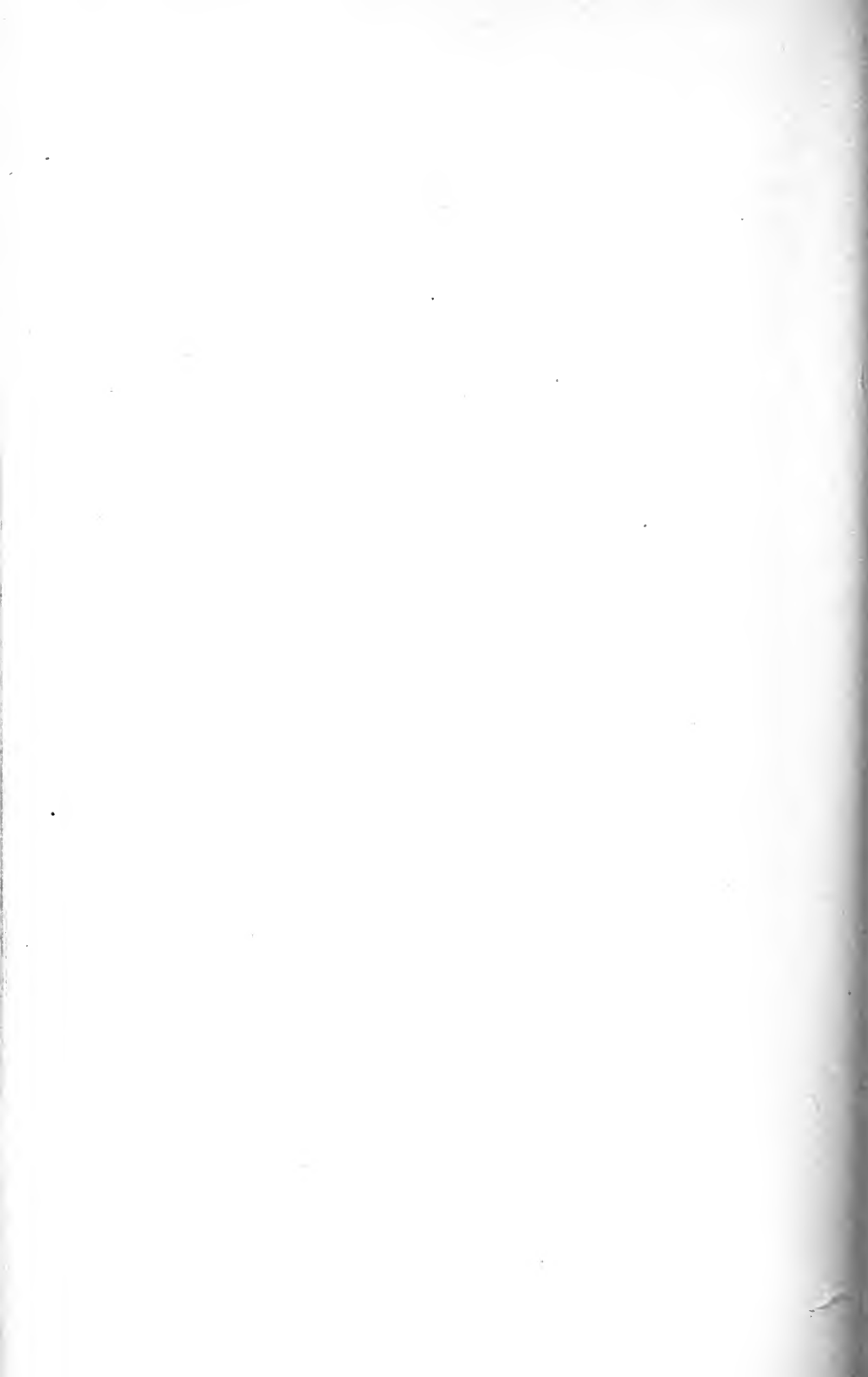
(d) *By the Centrifuge*.—The centrifuge, modified and adapted for the purpose, affords a convenient and sufficiently accurate method for the determination of fat in milk.

PROTEIDS. The milk is diluted and treated with acetic acid and carbonic anhydride gas. The precipitated caseinogen is freed from fat, by washing with ether, dried, and weighed. The filtrate from the caseinogen is evaporated on the water bath and the albumin precipitated with acetic acid tannin solution. The tannin is removed by washing with dilute alcohol, and the albumin remaining is dried and weighed.

The total nitrogen in milk, from which the proteids may be calculated, is usually determined by Kjeldahl's method, for which reference must be made to special text-books.

The determination of the proteids in milk offers many difficulties, and is generally omitted in the ordinary clinical examination, as is, also, the test for sugar which follows.





LACTOSE. The milk is acidified with hydrochloric acid, boiled and filtered. The filtrate is boiled to convert the lactose into glucose, and the latter is determined by means of Fehling's solution (see under Sugar in Urine), or, the lactose may be directly titrated, 10 c.c. of Fehling's being decomposed by 0.0676 grammes of that carbohydrate.

TOTAL SOLIDS. (a) *By Calculation.*—An approximation, sufficiently accurate for clinical purposes, particularly in the examination of mother's milk, may be made by means of Hehner and Richmond's formula.

$$T = \frac{F + (0.2186 \times G)}{0.859}$$

T = Total Solids. F = Fat percentage, as determined by Feser's lactoscope, or by extraction with ether. G = Last two figures of the specific gravity; *e. g.*, if the specific gravity is 1030, then G = 30.

If the specific gravity and total solids be known, the fat can be calculated by the same formula transposed as follows:

$$F = 0.859 T - 0.2186 G;$$

or, if the milk is poor and has been skimmed,

$$F = 0.859 T - 0.2186 G - 0.05 \left(\frac{G}{T} - 2.5 \right).$$

(b) *By Weight.*—Two grammes of milk are accurately weighed in a platinum dish with about 10 grammes of dry sand or powdered gypsum. The milk is then evaporated and the whole carefully dried at 100° C., until a constant weight is obtained. The loss in weight gives the water of the milk, and, by difference, the total solids.

ASH. By incinerating the solids obtained in the last test, the percentage of ash may be determined, or, better, make a separate determination as follows: To 20 grammes of milk in a weighed dish add 6 c.c. of nitric acid, evaporate to dryness and burn at a low red heat until the ash is free from carbon.

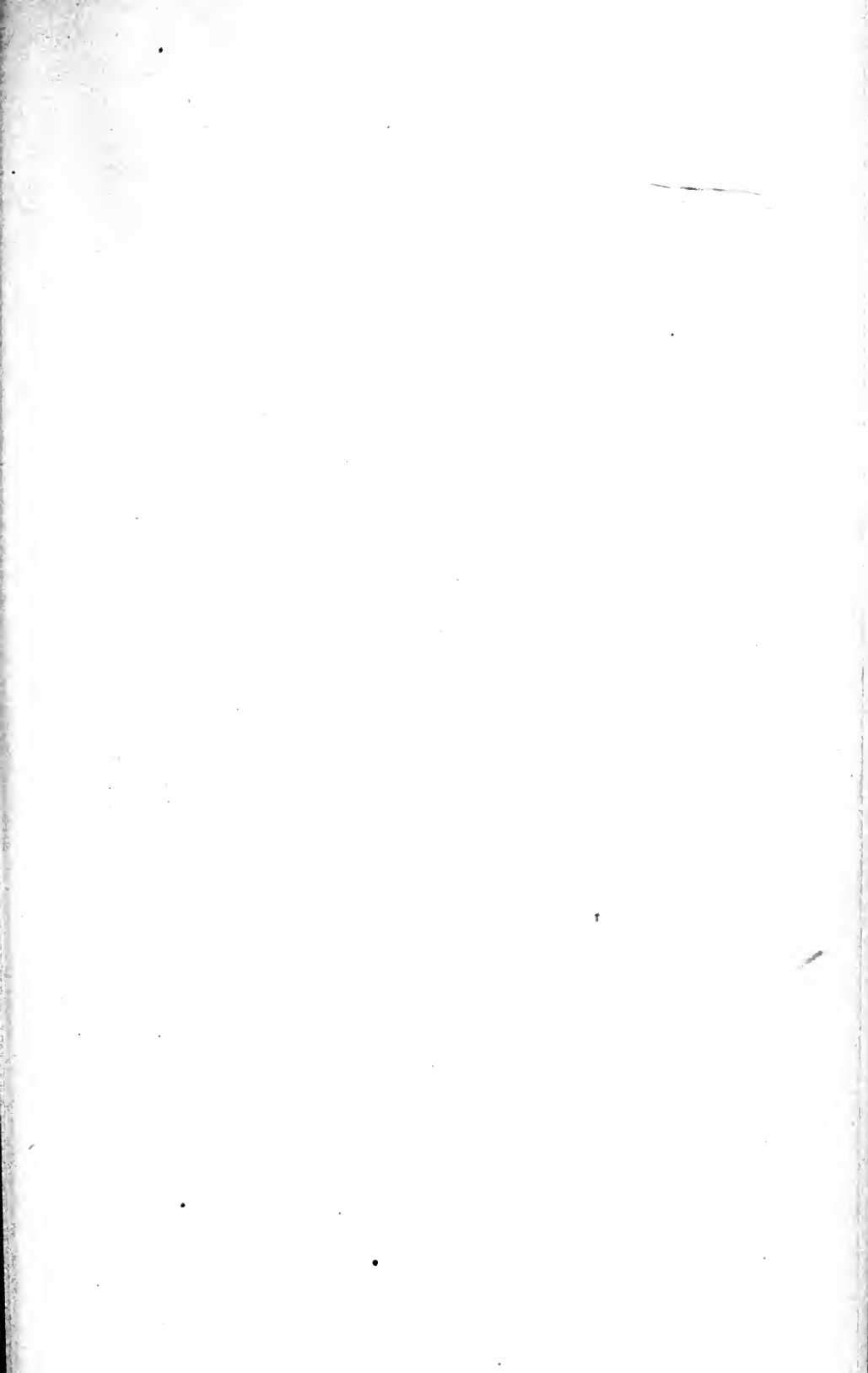
DETECTION OF ADULTERANTS IN MILK.

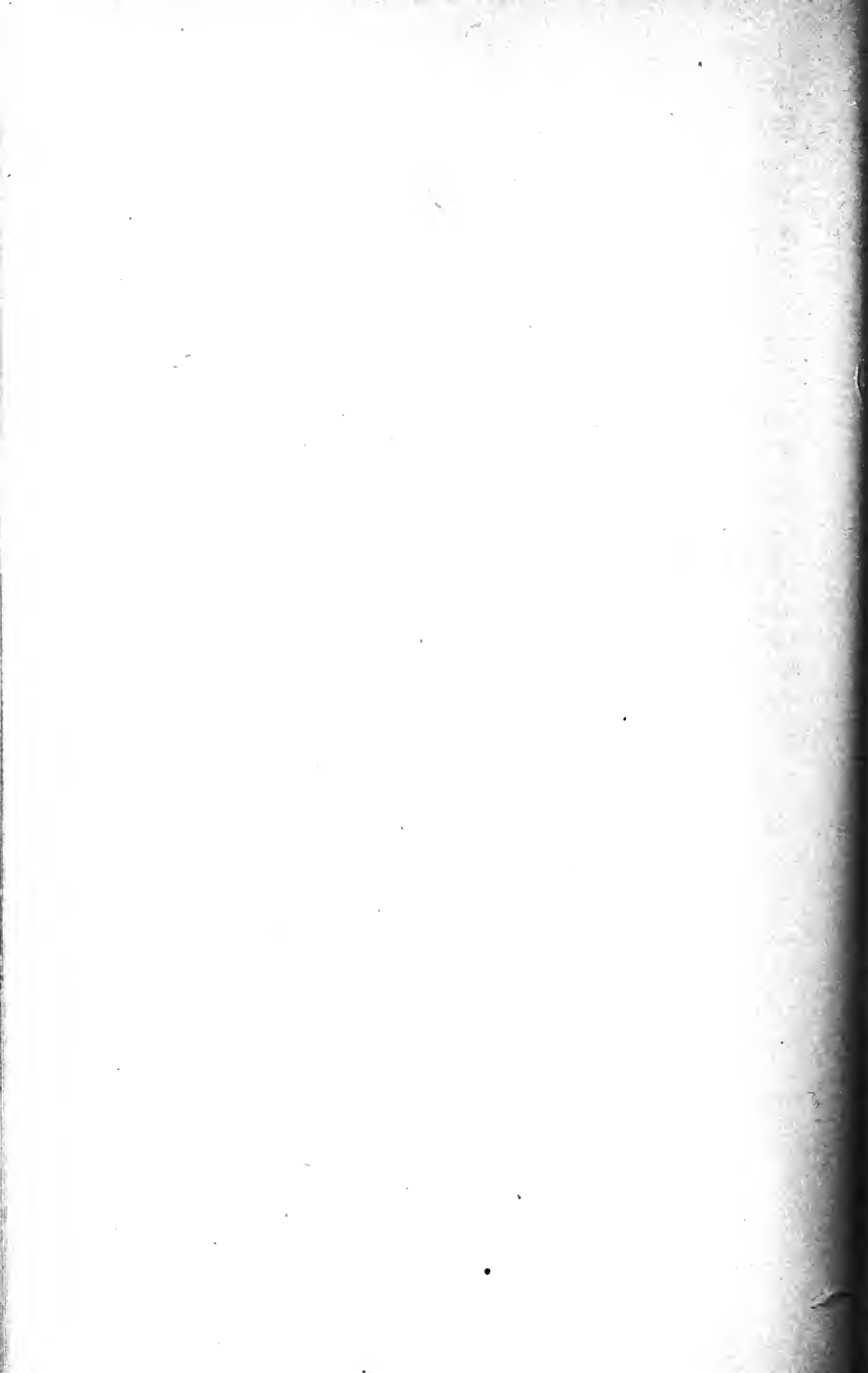
Certain substances, *e. g.*, *sodium carbonate*, *salicylic acid*, *borax*, *boric acid*, etc., are occasionally added to milk for the purpose of preservation. The presence of such substances will probably be indicated by an increase in the amount of ash, and special tests may then be applied. For *salicylic acid* and *salicylates*, acidify with

hydrochloric acid, filter, and shake the whey with ether. Evaporate the ether and test the residue (see p. 35). To test for *borax* place one drop of milk in a porcelain dish with 2 drops of strong hydrochloric acid and 2 drops of a saturated tumeric tincture. Dry on a water-bath and when cool, by means of a glass rod, add one drop of ammonia—a slate-blue color, changing to green, is developed if borax be present. To separate *borax* or *boric acid* from the milk for testing, 100 c.c. are heated to boiling in a covered beaker and 8 c.c. of nitric acid (1–50) are added. The milk is then cooled, filtered, one-eighth gramme of sodium carbonate added, evaporated to dryness and burned to a gray ash. The soluble portion of this ash is now tested (see p. 32).

Formaldehyde (Formalin), may be tested for as follows: Dilute 10 c.c. of milk with water and after the addition of 3 drops of acetic acid, add a little Mayer's solution. Filter, and add 1 c.c. of Schiff's reagent (see Appendix for solutions). After standing for about 10 minutes add 2 c.c. hydrochloric acid. The approximate amount of formalin present will be indicated by the depth of the violet color produced. As a second test, add to 10 c.c. of the sample, 2 c.c. of 0.1 per cent. phloroglucinol, and a few drops of sodium hydroxide. A reddish color is obtained when the milk contains four parts of formaldehyde per million. The reaction is most pronounced with milk containing 0.5 per cent., and fails with solutions containing more than 3.0 per cent.

Of adulterants proper, *water* is by far the most common and will be detected by variation in the specific gravity, total solids, etc. *Annatto*, added to increase the rich appearance of the milk, is not of itself harmful. Its presence may be detected by rendering the milk alkaline and soaking in it strips of filter paper. These latter will gradually acquire a yellow tint. *Starch* may be tested for by the addition of iodine solution, a blue color being developed. *Cane Sugar* will reveal itself in the taste and in the proportion of total solids, as well as in the percentage of sugar found. Boil 10 c.c. of the milk with 0.1 gramme of resorcinol and 1.0 c.c. of hydrochloric acid for five minutes. In presence of cane sugar a red color is obtained. *Chalk* will be deposited on standing, and may be tested for in the ash. Other substances, but rarely met with, are glycerol, magnesium carbonate, tragacanth, dextrin, and arrow-root. These will increase the total solids, and may be identified by special tests.





WATER ANALYSIS.

A WATER may be examined *microscopically* for the determination of the living forms contained, for the low orders of vegetable life, the fungi, for disease germs, etc., or it may be examined *chemically* for dissolved mineral salts and for evidence of pollution by sewage or by excreta. The microscopical examination, unfortunately, has proved of little value owing to the present impossibility of positively differentiating the harmless from the disease-producing germ, and to the obvious difficulty of properly representing within the boundary of a microscopic field the general contents of any considerable body of water. Microscopically we seek evidence of cholera, of typhoid; chemically we seek evidence of the pollution by which such germs, or others, might obtain entrance to the source of supply. If the water be contaminated it is a menace to health, whether or not the germs of a particular disease happen to be present at the moment, and in the actual quart, or gallon, withdrawn for examination. The chemical analysis of water is, however, a matter for the expert, and it is rare that a simple clinical test will be of value.

METHODS OF ANALYSIS.

COLOR.—The color of a water is determined, in common practice, by half filling a two-foot white glass cylinder fitted with flat plate ends. The cylinder is held horizontally before an illuminated white surface, and the water column then viewed throughout its length.

ODOR.—The odor, if any, is noted before and after heating, the water being placed in a stoppered flask.

REACTION.—The reaction, which is normally faintly acid, is tested with lacmoid (blue with alkalies, red with mineral acids, but unaffected by carbonic acid) and with phenolphthalein (deep red with alkalies, colorless with acids, including carbonic acid).

TOTAL SOLIDS.—100 c.c. of the water are evaporated in a care-

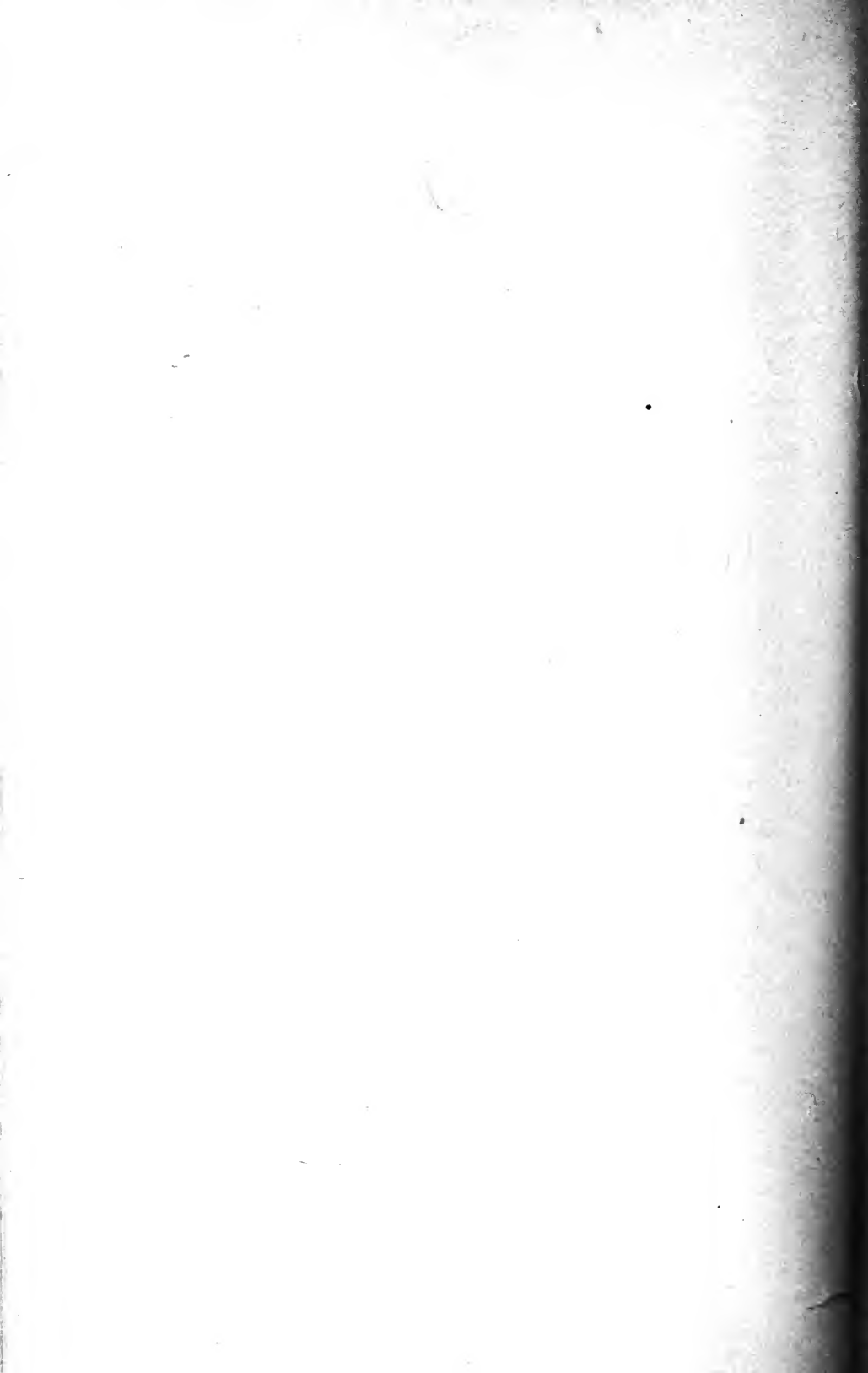
fully weighed platinum dish. After drying, the weight of the dish plus residue is determined, and the weight of the residue then obtained by difference. By now igniting the residue at a low red heat, organic matter and some volatile mineral compounds are removed; cooling and weighing, we determine, by calculation, the *organic and volatile solids*, the *mineral and non-volatile solids*.

CHLORINE.—A standard solution of silver nitrate is prepared, of such strength (4.793 grammes per litre) that each c.c. is equivalent to 0.001 gramme of chlorine, or, the deci-normal silver nitrate solution described on page 64 may be used. To 100 c.c. of the water (if chlorine be very small in amount evaporate 250 c.c. of water to 100 c.c.) add a few drops of potassium chromate solution, and then, from a burette, add the standard silver solution until a faint, but permanent, reddish tint is developed. The number of c.c. of silver nitrate added, multiplied by the equivalent of each c.c., will give the amount of chlorine in the sample.

PHOSPHATES.—500 c.c. of the water are slightly acidified with nitric acid and evaporated to 50 c.c. Add a few drops of dilute ferric chloride, and then ammonium hydroxide in slight excess, filter, and dissolve the precipitate in a little hot dilute nitric acid. Evaporate the solution to 5 c.c., add 2 c.c. of a solution of ammonium molybdate, and warm. Phosphates are thrown down as a yellow precipitate, the amount of precipitate indicating the amount of phosphate present.

NITROGEN OF AMMONIUM AND OF ALBUMINOID COMPOUNDS.—*Solutions required.* **Sodium Carbonate:**—50 grammes of the pure salt, strongly heated, dissolved in 250 c.c. of distilled water and boiled down to 200 c.c. **Standard Ammonium Chloride:**—0.382 gramme pure, dry, ammonium chloride, dissolved in 100 c.c. ammonia-free water. For use, 1 c.c. of this solution is diluted to 100 c.c., each c.c. of the diluted solution being then equivalent to 0.00001 gramme of nitrogen. **Ammonia-free Water:**—Acidulate distilled water with sulphuric acid and redistil from a glass retort. **Nessler's Reagent:**—35 grammes of potassium iodide are dissolved in 100 c.c. of water; 17 grammes of mercuric chloride are dissolved in 300 c.c. of water and added to the potassium iodide solution until a slight permanent precipitate is obtained. Dilute the mixture to 1000 c.c. with 20 p. c. sodium hydroxide, and again add the mercuric chloride until a slight permanent precipitate is obtained. **Alkaline Potassium Permanganate:**—200 grammes of potas-





sium hydroxide and 8 grammes of potassium permanganate are dissolved in 1000 c.c. of distilled water, boiled down to 750 c.c., and again made up to 1000 c.c. with ammonia-free water.

Nitrogen of Ammonium Compounds.—Place in glass retort, properly connected with a condenser and receiver, 200 c.c. of distilled water and 10 c.c. of the sodium carbonate solution. Distil until on testing the distillate with Nessler's reagent no reaction is obtained. Introduce now, 500 c.c. of the water under examination, and continue the distillation at such a rate that 50 c.c. of distillate will be obtained in each 10 minutes. To each 50 c.c., collected separately, add 2 c.c. of Nessler's reagent, and compare the color obtained with a standard made up of a measured amount of the ammonium chloride diluted to 50 c.c. with ammonia-free water, and having 2 c.c. of Nessler's reagent added. According as the color produced in the distillate is darker or lighter than that of the standard, prepare new standards containing more or less of the ammonium chloride until, finally, the color of standard and distillate is the same. The amount of nitrogen in the 50 c.c. of distillate will then be equal to the known amount of nitrogen in the ammonium chloride of the standard used. Continue the distillation and the "Nesslerizing" until no further color is obtained. The sum of the nitrogen in the distillates will give the "nitrogen of ammonium compounds" in the 500 c.c. sample under analysis.

Nitrogen of "Albuminoid" Compounds.—Rinse out the retort and introduce 200 c.c. of distilled water and 50 c.c. of the alkaline potassium permanganate. Distil until the distillate gives no reaction with Nessler's reagent. Introduce 500 c.c. of the water under examination, distil, and "Nesslerize," as described in the last paragraph. Subtracting the nitrogen of ammonium compounds, already determined, from the nitrogen of this second operation, we obtain the "nitrogen of albuminoid compounds."

NITROGEN AS NITRATES.—*Solutions required.* *Phenol-sulphonic acid:*—37 c.c. of strong sulphuric acid added to 3 c.c. of water, with 6 grammes of pure phenol. *Standard Potassium Nitrate:*—0.722 grammes of pure, fused, potassium nitrate in 1000 c.c. of water. Each c.c. of this solution contains 0.0001 gramme of nitrogen.

Process.—Evaporate a measured volume of water to dryness in a platinum dish, add 1 c.c. of phenol-sulphonic acid, and, after thoroughly mixing with the residue, add 1 c.c. of water and 3

drops of strong sulphuric acid. Warm on the water bath, add 25 c.c. of water, and an excess of ammonium hydroxide, then add water to 100 c.c. Compare the color of the solution (a yellow) with that obtained by similarly treating 1 c.c. of the standard potassium nitrate. The darker solution is diluted until the colors are equal. The amount of dilution being measured, and the amount of nitrogen in the 1 c.c. of standard being known, the nitrogen of the sample, nitrogen as nitrates, may be easily calculated.

NITROGEN AS NITRITES.—*Solutions required.* *Sulphanilic Acid*:—0.5 gramme dissolved in 150 c.c. of acetic acid, sp. gr. 1.04. *Alpha-amido-naphthalene acetate*:—0.1 gramme of solid naphthylamine is boiled with 20 c.c. of water, filtered through cotton, and mixed with 180 c.c. of diluted acetic acid. The water used must be free from nitrites.

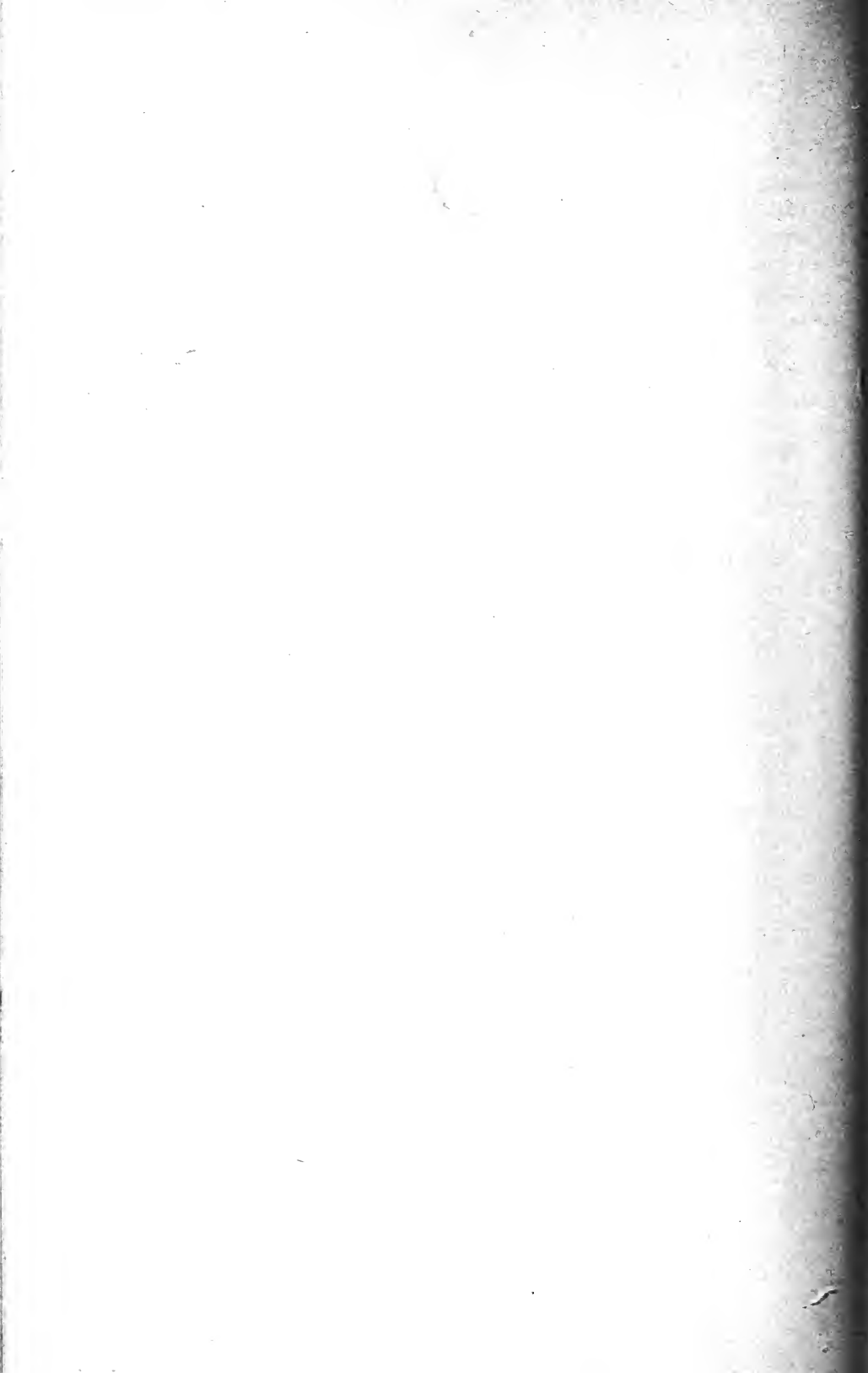
Process.—To 25 c.c. of the water add 2 c.c. of the sulphanilic acid and 2 c.c. of the amido-naphthalene acetate. In presence of nitrites a pink color is produced, the intensity of the color and the rapidity of its development being proportionate to the amount of nitrite present.

HARDNESS OF WATER.—Water may be “temporarily hard” from presence of carbonates of calcium or magnesium, it may be “permanently hard” from presence of the sulphates of the same elements. *Hehner's Method; Solutions required*—*Sodium Carbonate*:—1.06 grammes of recently ignited sodium carbonate are dissolved in 1000 c.c. of water. Each c.c. of this solution is the equivalent of 0.001 gramme of calcium carbonate. *Standard Sulphuric Acid*:—1 c.c. of the strong acid is dissolved in 1000 c.c. of water and tested with the sodium carbonate solution, using lacmoid as the indicator. The sulphuric acid is then diluted until 1 c.c. will exactly neutralize 1 c.c. of the sodium carbonate, each c.c. of the acid solution being thus made equivalent to 0.001 gramme of calcium carbonate.

Process. For the determination of the *temporary hardness*, 100 c.c. of the water, tinted with lacmoid, are heated just to boiling, and the sulphuric acid added until the color changes. Each c.c. of the acid used represents 0.001 gramme of calcium carbonate in the sample taken.

For the determination of the *permanent hardness*, to 100 c.c. of the water add a measured excess of the sodium carbonate solution, and evaporate to dryness in a platinum dish. Mix the residue





with boiling distilled water, filter and titrate the still hot filtrate with the acid. The difference between the number of c.c. of acid used and the number of c.c. of sodium carbonate added, gives the permanent hardness in terms of calcium carbonate.

DETECTION OF METALS.—In general, a measured volume of water may be evaporated to a small bulk and examined by the regular scheme (p. 25), remembering the possible presence of phosphates. Arsenic, antimony, and mercury may be tested for, also, by the special tests, pages 41–43. Lead will be precipitated as the brownish-black sulphide on addition of a few drops of ammonium sulphide, the precipitate being insoluble in dilute hydrochloric acid (distinction from iron); insoluble in potassium cyanide (distinction from copper). Iron may be tested for, directly, by boiling with a drop of strong nitric acid and then adding potassium sulphocyanate, a blood-red color or faint reddish tint indicating iron in large or small amount.

CLINICAL TESTS.—The *Total Solids*, *Volatile Matter*, etc., may be determined as described. *Chlorine* may be easily determined as described, or it may be tested for qualitatively, by merely adding a drop of silver nitrate solution, best after first acidulating with nitric acid. *Phosphates* may be tested for as described, or by the following—Heisch's Test: Fill a 100 c.c. flask with the water and add 0.5 gramme of pure crystallized sugar. Cork the flask and let it stand in the sunlight, at a temperature of 27° C. for several hours. A turbidity, due to a growth of micro-organisms, indicates the presence of phosphates.

An excess of *Ammonium Compounds* may be shown, without previous distillation, by the direct addition of a few drops of Nessler's reagent—a brownish color, or if the ammonium compounds be present in very large amount, a brownish precipitate, will be obtained. (Experiment with pure water, with well water, with water to which a drop of very dilute ammonium hydroxide has been added, etc.) *Nitrites*, *Nitrates*, and the *Metals*, may all be tested for as described. The presence of *Calcium* may be demonstrated by addition to the water of ammonium chloride, ammonium hydroxide, and ammonium oxalate. *Sulphates* are shown by adding barium chloride after first acidulating with hydrochloric acid.

INTERPRETATION OF RESULTS.

The interpretation of the results of analysis will be governed by

the character of the water, whether "surface," "subsoil," "deep well," or "spring," and also by the local conditions as regards soil, cultivation, population, proximity to the sea, etc.

The presence of a marked *Color*, *Odor*, or *Taste*, will at once suggest a contamination more or less serious, but, on the other hand, a water may be perfectly normal in these respects and still may be dangerously polluted. The *Total Solids* carried by natural waters vary greatly in amount; 600 parts per million is generally regarded as the permissible maximum. With an increase in mineral matter the water passes into the category of mineral waters and becomes a medicinal agent. Organic matter of animal origin should be entirely absent, nor should vegetable matter be present in large amount.

Chlorine, as sodium chloride, is a constituent of many soils and in certain localities, notably near the sea, may be present in considerable amount. In absence of such natural origin, however, chlorine is suggestive of animal pollution, the chlorides being constant and indestructible elements of all sewage and excreta. Unless accounted for by mineral sources, chlorine exceeding 10 parts per million is to be regarded with suspicion.

Phosphates should not exceed 0.6 part per million, phosphates like chlorides being characteristic of the excreta. If a marked turbidity, and especially if the odor of butyric acid, develop with the Heisch clinical test, the water is to be regarded as contaminated. Negative results with phosphate tests, however, are not conclusive evidence of freedom from contamination. *Nitrogen of Ammonium and Albuminoid Compounds*. The nitrogen of *ammonium compounds* (the so-called "free ammonia") is subject to considerable variation, but when in large amount suggests organic contamination. The permissible limit is generally placed at 0.2–0.5 part per million, though, except with certain deep waters, an uncontaminated water does not often average more than 0.04–0.05 part per million. The determination has little value, however, unless considered with the nitrogen of *albuminoid compounds* (the so-called "albuminoid ammonia"). When the nitrogen of albuminoid compounds is less than 0.02 part per million, the water is generally free from organic pollution. If the nitrogen of albuminoid compounds be above 0.05 part per million, and there be a considerable amount of the ammonium compounds, the water may be contaminated; but if the ammonium compounds be low,



the water will be acceptable until the albuminoid nitrogen reaches 0.08 part per million, when the chlorine must be taken into account. The *Nitrites* are usually evidence of existing fermentative changes and should be absent. The *Nitrates* represent the final stage in the oxidation of nitrogenous organic compounds, or, they may be derived from the mineral salts of the soil. In general, 5 or 6 parts per million is regarded as a permissible maximum. The *Hardness* of water is not of sanitary importance unless excessive. It is of interest more especially as regards the use of the water in steam boilers, in the laundry, etc.

It is to be understood that the figures given above are subject to local modification. It is, in fact, impossible to present a set of rigid standards universally applicable; the exact interpretation of a water analysis can only be obtained as a result of experience.

EXAMPLES OF WATER ANALYSES.

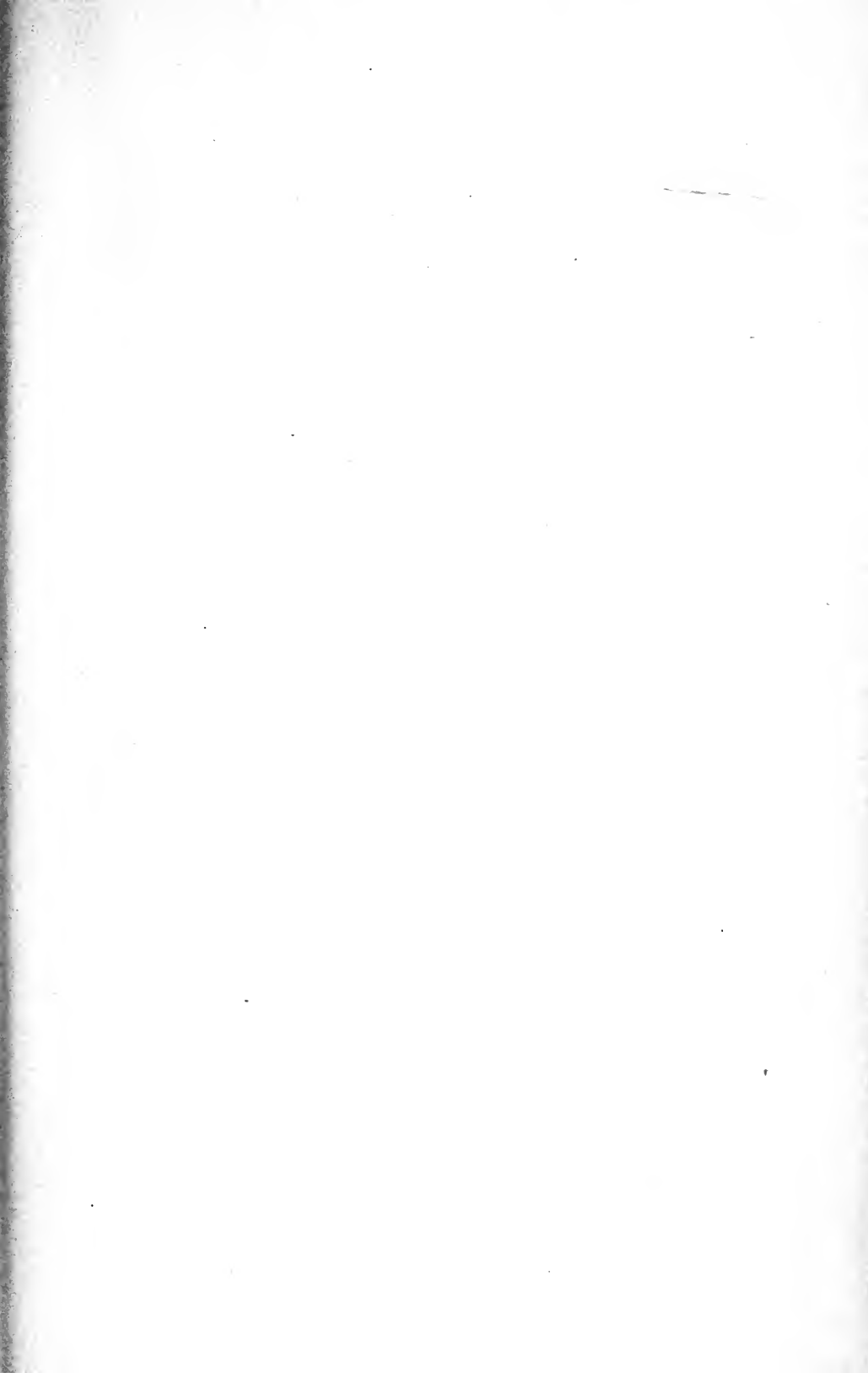
(In parts per million.)

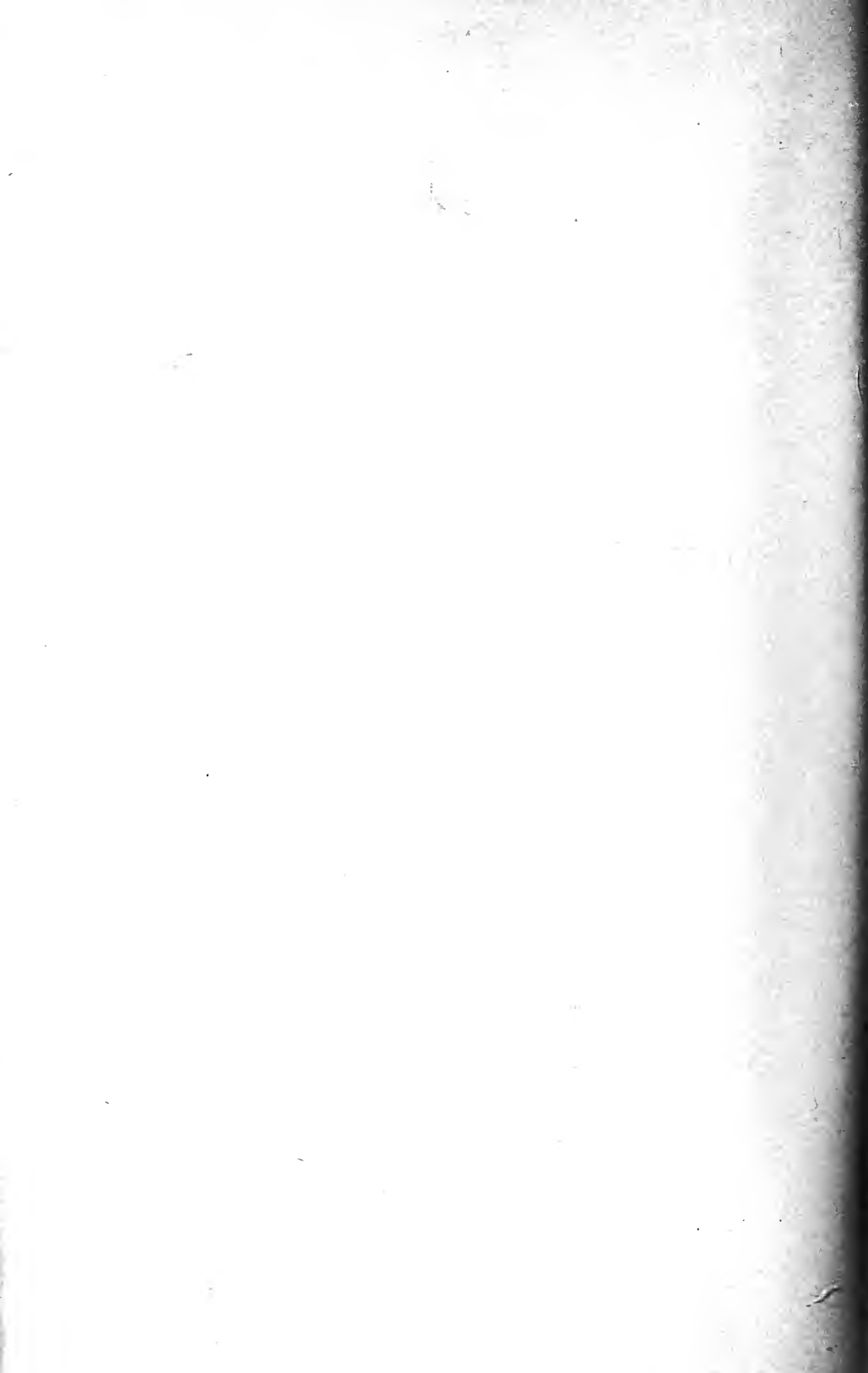
	Total Solids.	Chlorine.	N. of Ammonium Compounds.	N. of Albuminoid Compounds.	N. of Nitrites.	N. of Nitrates.
Rain water,* Bellefonte, Pa.	5.0	Absent.	0.28	0.148	Absent.	Absent.
Schuylkill River Water—						
Muddy *	180.0	—	Absent.	0.180	Trace.	0.25
Filtered	146.0	5.0	0.06	0.090	Absent.	Present.
Distilled	13.0	Absent.	0.086	0.012	Absent.	Absent.
Driven Well, 109 feet.						
Devon, Pa. <i>Pure</i> .	91.0	7.0	0.030	0.014	Absent.	1.2
Driven Well, 75 feet.						
Philadelphia, Pa.						
Contaminated	330.0	35.4	0.306	0.070	Present.	20.0
Contaminated Well,						
Passaic Co., N. J.	709.0	123.0	0.068	0.030	Present.	12.6
Artesian Well,* Philadelphia, Pa. . . .	—	89.21	0.248	0.032	Trace.	Trace.
Spring Water, <i>Pure</i> .						
Haverford, Pa. . . .	66.0	7.0	0.028	0.024	Absent.	2.8

NOTE.—Analyses marked with asterisk (*) are from Leffmann and Beam, other results are from complete analyses by the author.

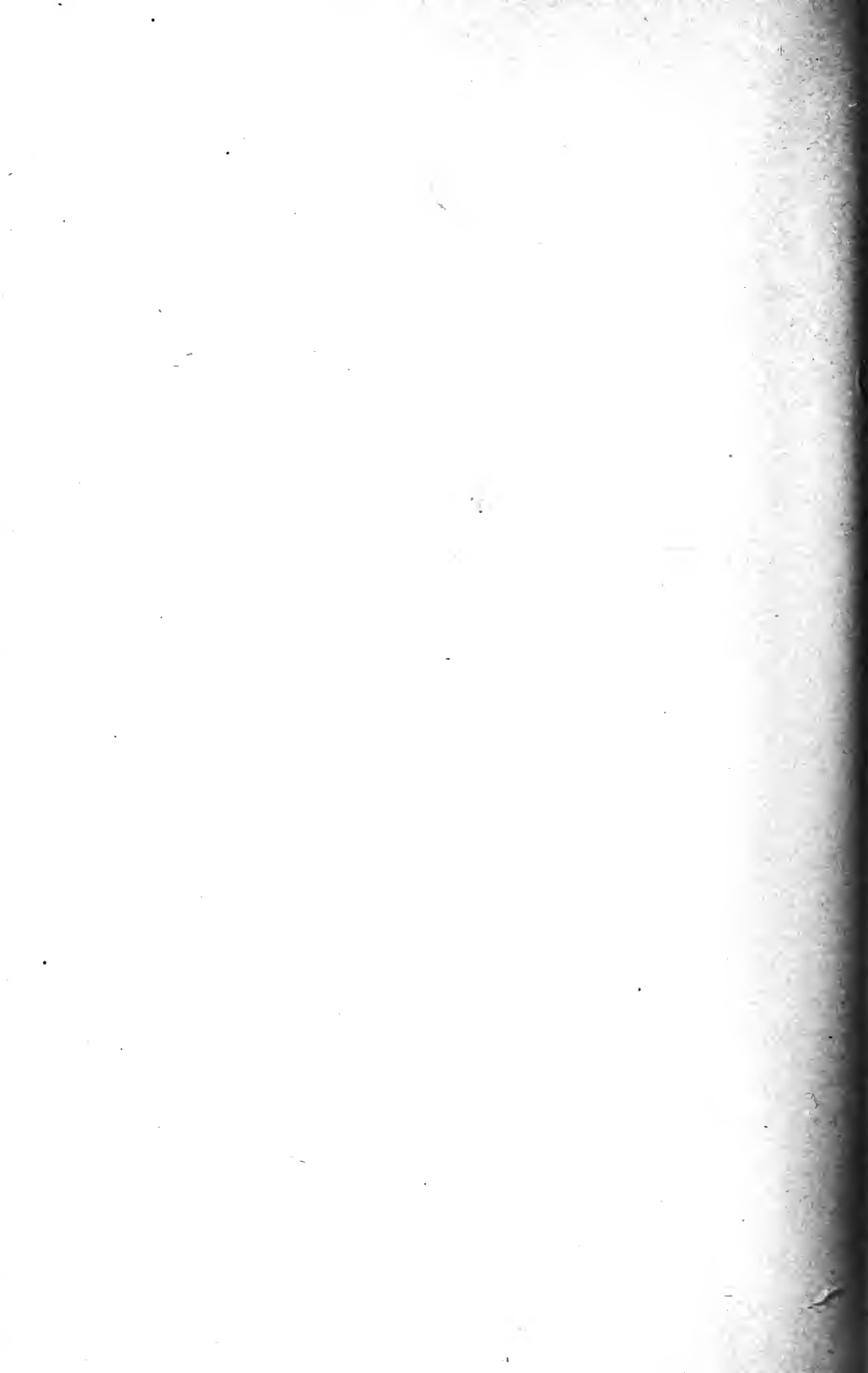
The filtered river water is not of the same date as that marked "muddy." The distilled water was obtained by an ordinary continuous distillation on a large scale. Results in parts per million may be converted into grains per U. S. gallon by multiplying by 0.0584—or into grains per Imperial gallon, multiplying by 0.07.

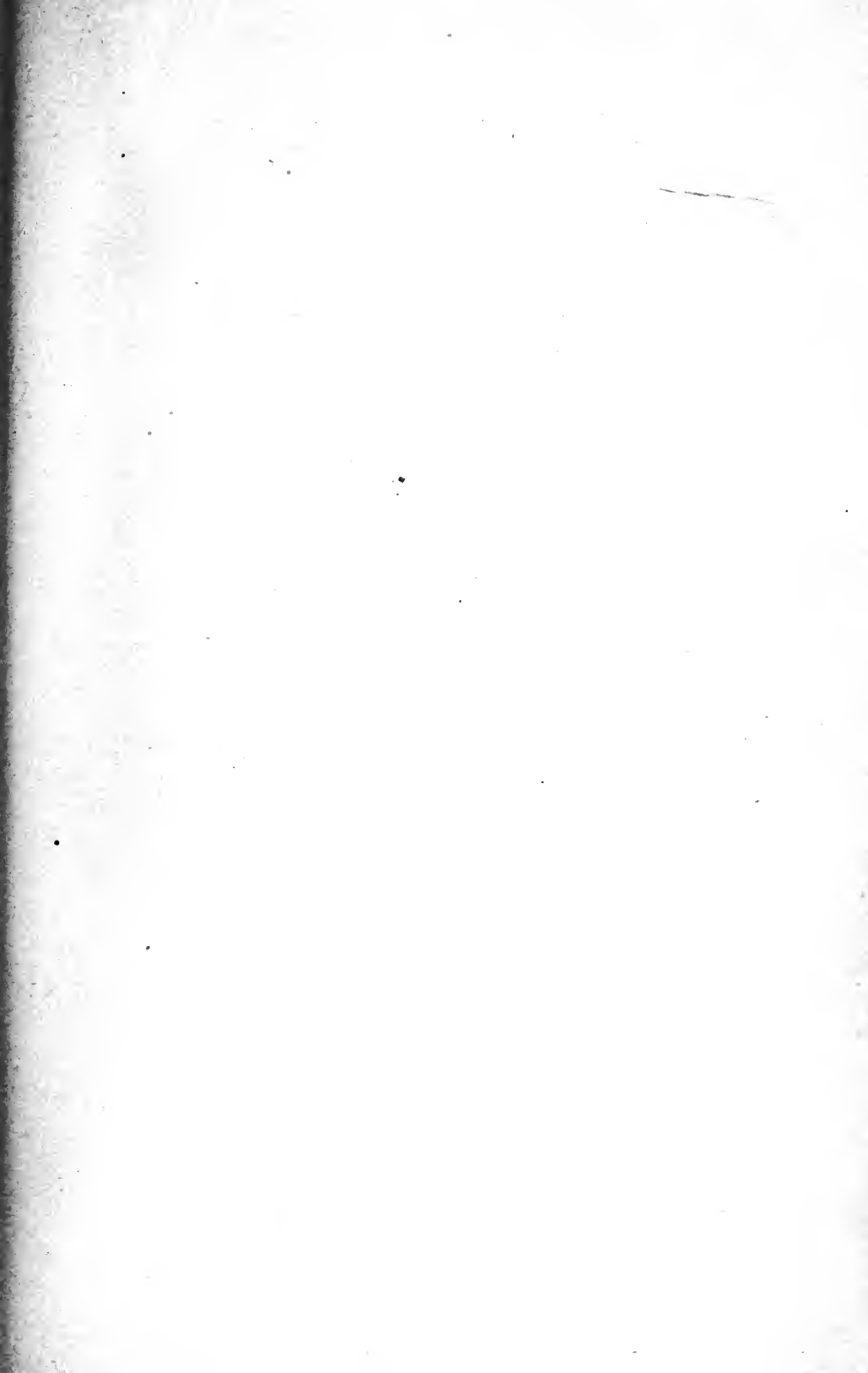


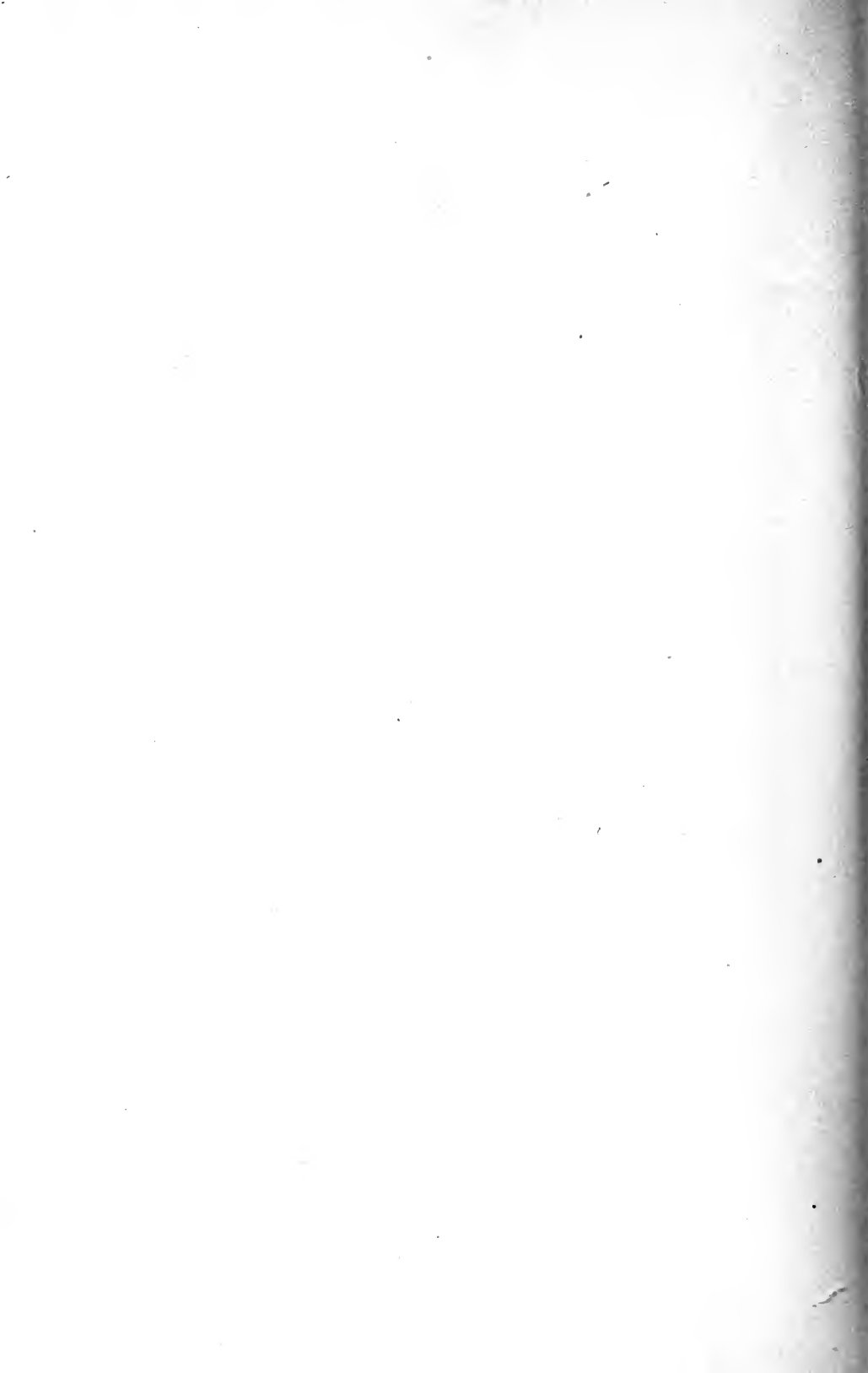




APPENDIX.







WEIGHTS AND MEASURES.

MEASURES OF WEIGHT.

1 milligramme	=	0.001 gramme	=	0.01543 grains, Troy.
1 centigramme	=	0.010 "		
1 decigramme	=	0.100 "		
1 gramme	=	1.000 "	=	15.43235 grains, Troy.
1 decagramme	=	10.000 grammes.		
1 hectogramme	=	100.000 "		
1 kilogramme	=	1000.000 "	=	2.6790 pounds, Troy.
1 kilogramme			=	2.2046 pounds, Av.
1 tonneau	=	1000.000 kilogrammes.		

TROY WEIGHT.

Pound.	Ounces.	Pennyweights.	Grains.	Grammes.
1	12	240	5760	= 373.2419
	1	20	480	= 31.1035
		1	24	= 1.5552

APOTHECARIES' WEIGHT.

Pound.	Ounces.	Drachms.	Scruples.	Grains.	Grammes.
1	12	96	288	5760	= 373.2419
	1	8	24	480	= 31.1035
		1	3	60	= 3.8879
			1	20	= 1.2959
				1	= 0.0648

AVOIRDUPOIS WEIGHT.

Pound.	Ounces.	Drachms.	Grains.	Grammes.
1	16	256	7000	= 453.5926
	1	16	437.5	= 28.3495
		1	27.343	= 1.7718

GRAMMES AND GRAINS.

Grammes.		Grains.	Grains.	Grammes.
1	=	15.43235	1	= 0.06479
2	=	30.86470	2	= 0.12958
3	=	46.29705	3	= 0.19437
4	=	61.72940	4	= 0.25916
5	=	77.16175	5	= 0.32395
6	=	92.59410	6	= 0.38874
7	=	108.02645	7	= 0.45353
8	=	123.45880	8	= 0.51832
9	=	138.89115	9	= 0.58311

MEASURES OF CAPACITY.

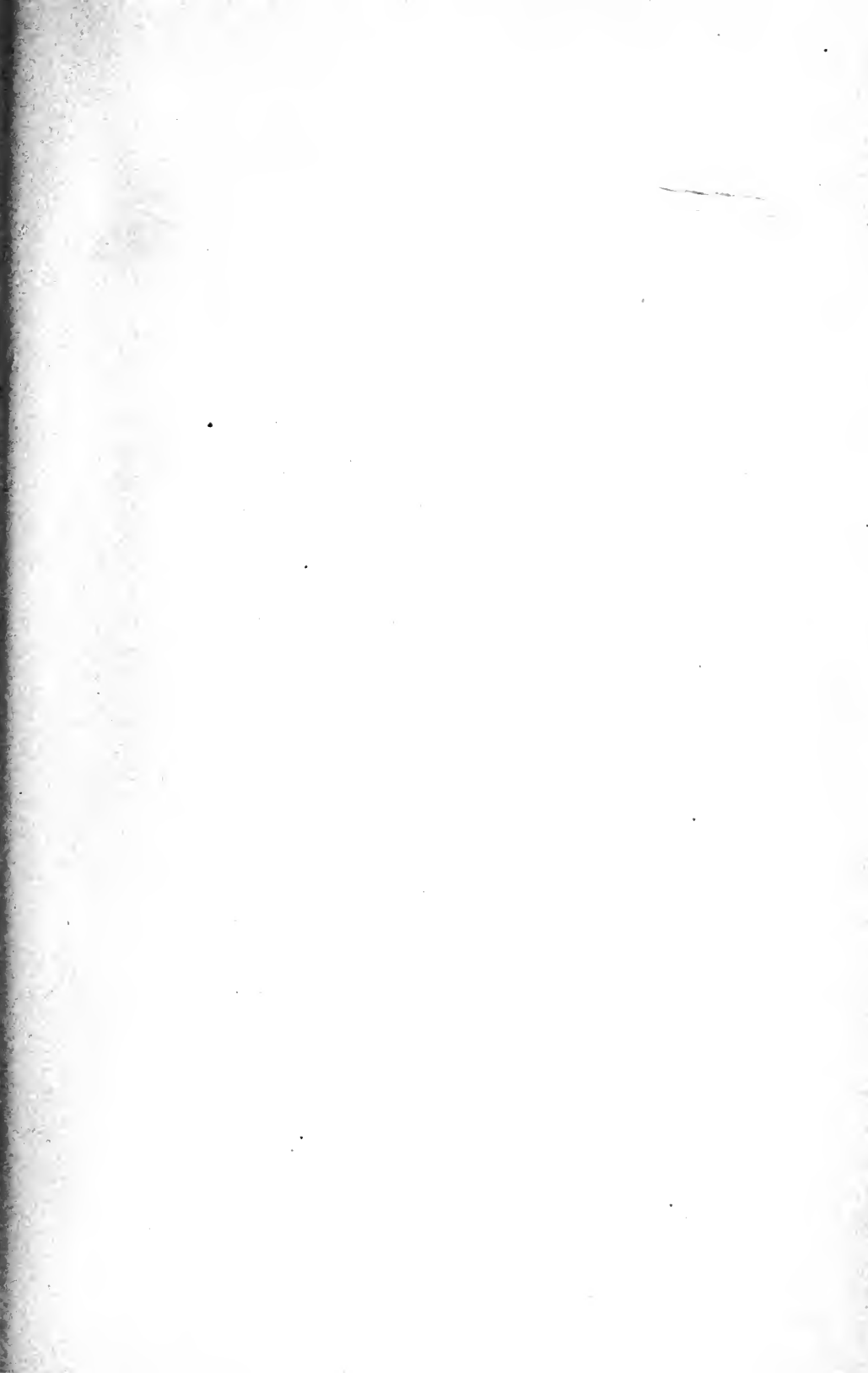
1 millilitre = 1 cubic centimetre	=	0.061027 cubic inch.
	=	0.033816 U. S. fluid ounce.
	=	16.2310 U. S. minims.
1 litre = 1000 cubic centimetres	=	33.816 U. S. fluid ounces.
	=	35.219 Imperial "
	=	1.0567 U. S. quart.
1 kilolitre = 1000 litres	=	264.18 U. S. gallons.

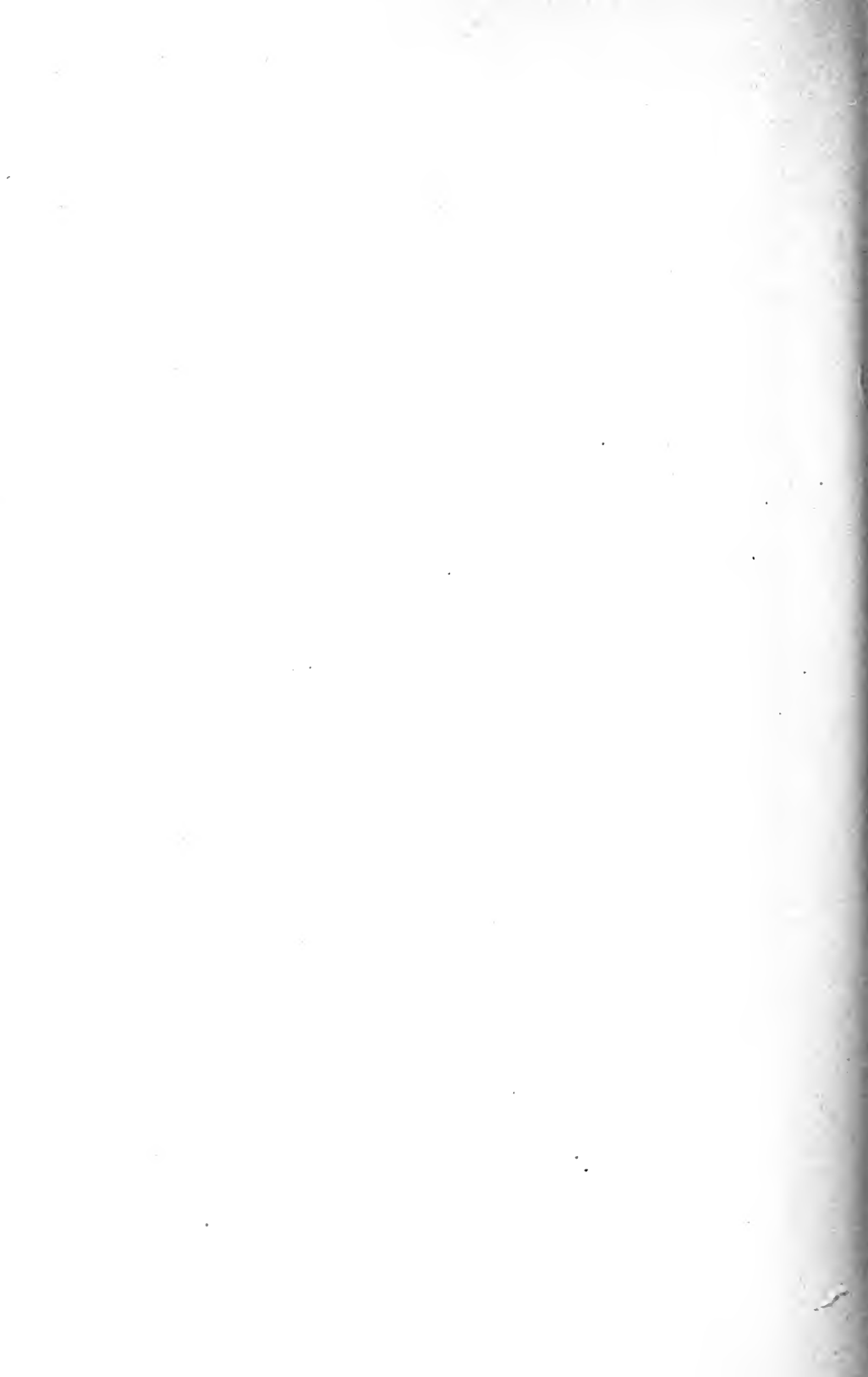
APOTHECARIES' OR WINE MEASURE (U. S.).

Gallon.	Pints.	Fluid Ounces.	Fluid Drachms.	Minims.	Cubic Centimetres.
1	8	128	1024	61440	= 3785.432
(58418.14 grains)	1	16	128	7680	= 473.179
		1	8	480	= 29.574
			1	60	= 3.696
				1	= 0.0616

IMPERIAL MEASURE.

Gallon.	Pints.	Fluid Ounces.	Fluid Drachms.	Minims.	Cubic Centimetres.
1	8	160	1280	76800	= 4543.487
(70,000 grains)	1	20	160	9600	= 567.936
		1	8	480	= 28.396
			1	60	= 3.549
				1	= 0.059





MEASURES OF LENGTH.

1 millimetre	=	0.001 metre	=	0.03937 inch.
1 centimetre	=	0.010	"	
1 decimetre	=	0.100	"	
1 metre	=	1.000	"	= 3.28089 feet.
1 decametre	=	10.000	metres.	
1 hectometre	=	100.000	"	
1 kilometre	=	1000.000	"	= 0.62138 mile.

1 inch	=	2.53995 centimetres.
1 foot	=	0.30479 metre.
1 yard	=	0.91438 metre.
1 mile	=	1.60931 kilometres.

MEASURES OF TEMPERATURE.

	Water boils.	Water freezes.
Centigrade	100°	0°
Fahrenheit	212°	32°
Reaumur	80°	0°

To convert °C to °F, multiply by 9, divide by 5, and add 32.

To convert °F to °C, subtract 32, multiply by 5, and divide by 9.

THE COMMON ACID RADICALS.

1. *Monobasic*.—Acetate, $C_2H_3O_2$; benzoate, $C_7H_5O_2$; bromide, Br; chlorate, ClO_3 ; chloride, Cl; cyanate, CNO ; cyanide, CN; fluoride, F; hypobromite, BrO ; hypochlorite, ClO ; hypophosphite, H_2PO_2 ; iodide, I; lactate, $C_3H_5O_3$; metaborate, BO_2 ; metaphosphate, PO_3 ; nitrate, NO_3 ; nitrite, NO_2 ; perchlorate, ClO_4 ; salicylate, $C_7H_5O_3$; sulphocyanate, CNS.

2. *Dibasic*.—Carbonate, CO_3 ; chromate, CrO_4 ; dichromate, Cr_2O_7 ; metasilicate, SiO_3 ; molybdate, MoO_4 ; oxalate, C_2O_4 ; phosphite, HPO_3 ; pyro(or tetra)borate, B_4O_7 ; sulphate, SO_4 ; sulphide, S; sulphite, SO_3 ; silicofluoride, SiF_6 ; thiosulphate, S_2O_3 = "hyposulphite" of pharmacy; tungstate, WO_4 .

3. *Tribasic*.—Arsenate, AsO_4 ; arsenite, AsO_3 ; borate, BO_3 ; citrate, $C_6H_5O_7$; ferricyanide, $Fe(CN)_6$; phosphate, PO_4 .

4. *Tetrabasic*.—Ferrocyanide, $\text{Fe}(\text{CN})_6$; orthosilicate, SiO_4 ; pyrophosphate, P_2O_7 .

CONSTRUCTION OF FORMULÆ.—The acid formulæ may be obtained from the above by prefixing H atoms, the number so prefixed being determined by the basicity, *e. g.* Hypochlorous acid = HClO . Thiosulphuric acid = $\text{H}_2\text{S}_2\text{O}_3$. Orthosilicic acid = H_4SiO_4 .

By comparison with the table of elements, p. 8, formulæ for common salts may readily be ascertained, *e. g.* To determine the formulæ for sodium salicylate, potassium sulphite, and calcium phosphate.

Sodium is univalent, the salicylate radical is univalent (monobasic), hence one sodium atom unites with one salicylate radical, giving the formula $\text{NaC}_7\text{H}_5\text{O}_3$.

Potassium is univalent, the sulphite radical is bivalent (dibasic), hence two potassium atoms unite with one sulphite radical, giving the formula K_2SO_3 .

Calcium is bivalent, the phosphate radical is trivalent (tribasic), hence three calcium atoms unite with two phosphate radicals, giving the formula $\text{Ca}_3(\text{PO}_4)_2$.

SOLUBILITIES OF COMMON SALTS.

GROUP I. Pb, Hg(ous), Ag. *Soluble in Water*.—Nitrates, and nitrites of all. Ag, Pb; acetates. Pb; chloride (in hot water).

Insoluble in Water, Soluble in Acids.—Carbonates, oxalates, oxides, phosphates, sulphides, tartrates, of all. Ag, Hg; sulphates.* Ag; bromide. Pb; iodide.* Hg; iodide.

Insoluble in Water and Acids.—Ag; chloride, cyanide, iodide. Pb; chromate,† sulphate.† Hg; chloride.†

GROUP II (a). As, Sb, Sn. *Soluble in Water*.—As; Arsenates and arsenites of alkalies, chloride and iodide (decomposed by hot water). Sb; chloride (decomposed by excess of water), tartrate. Sn(ous); chloride, sulphate. Sn(ic); chloride.

Insoluble in Water, Soluble in Acids.—As; arsenates and arsenites of metals other than alkalies, oxide,* sulphide. Sb; oxide, sulphide. Sn; oxide, sulphide. Sn(ic) oxide.†

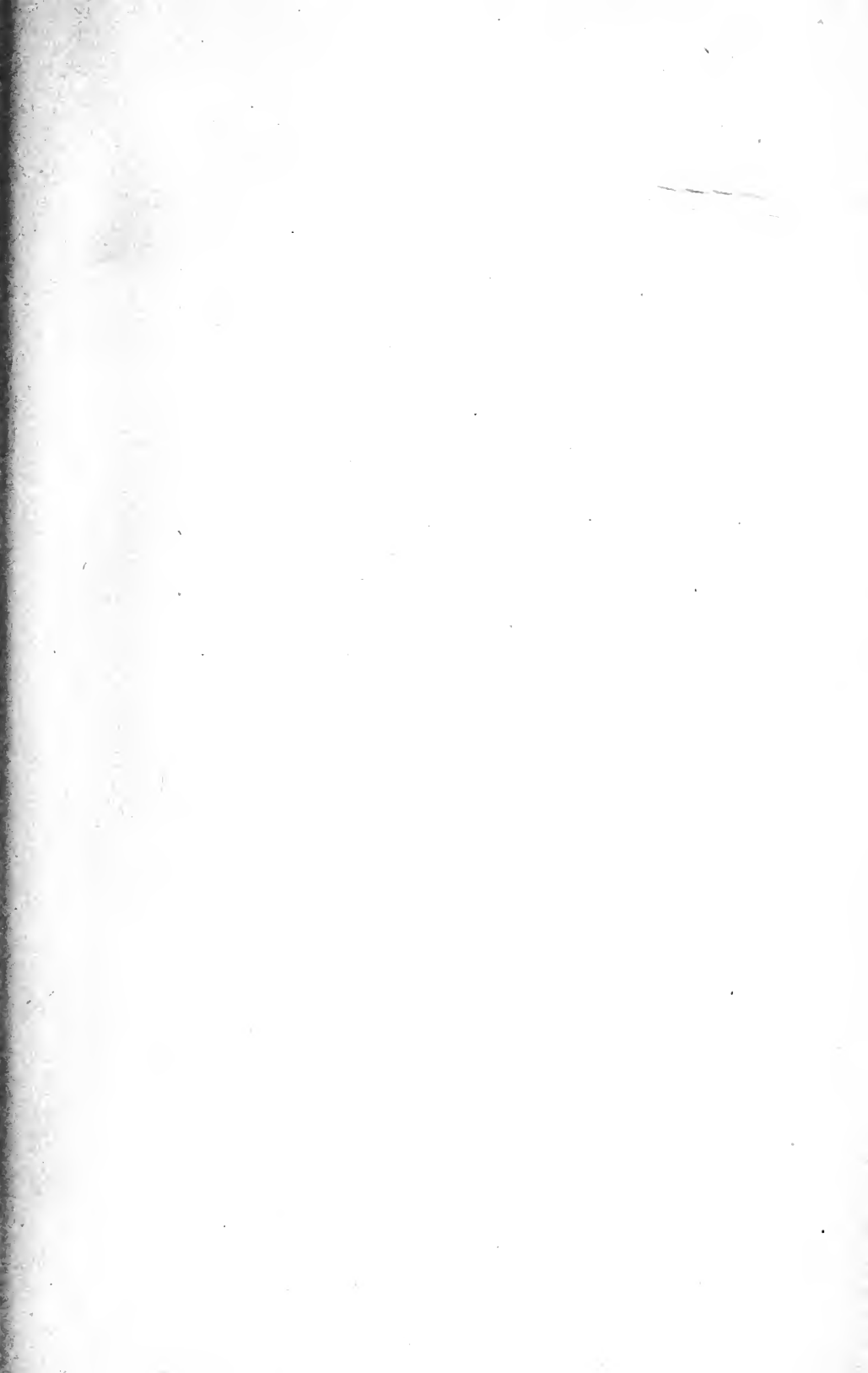
GROUP II (b). Hg(ic), Cu, Bi, Cd. *Soluble in Water*.—Acetates, chlorides, nitrates, sulphates, of all. (Bi; chloride and nitrate decomposed by excess of water.) Cu(ous), Cd; iodides.

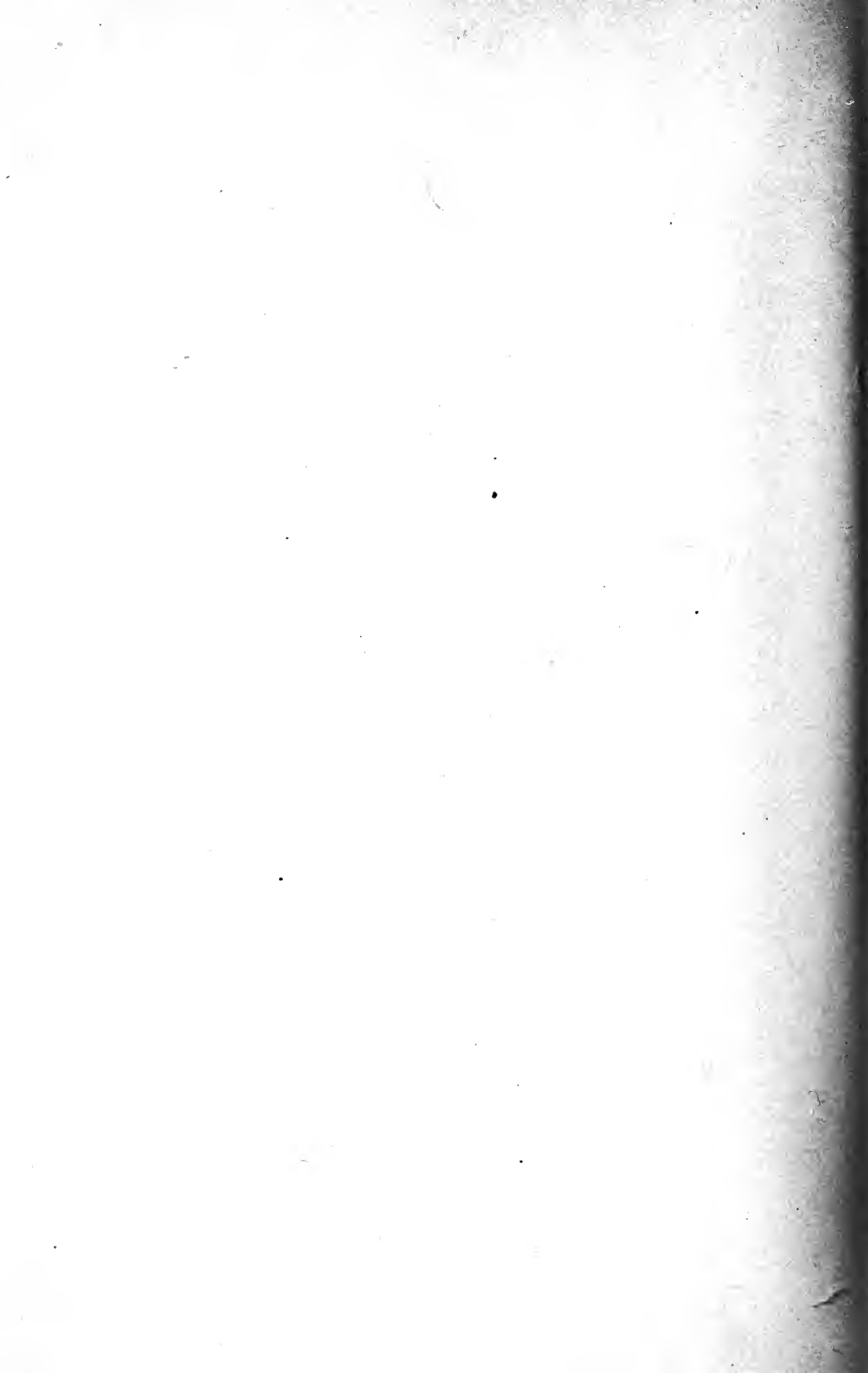
Insoluble in Water, Soluble in Acids.—Carbonates, oxides, phosphates, sulphides, of all. Bi; oxychloride, oxynitrate, sub-carbonate.

Insoluble in Water and Acids.—Cu; ferrocyanide. Hg; oxysulphate.†

* Sparingly soluble in water.

† Sparingly soluble in acids.





GROUP III. Fe, Cr, Al, Mn, Zn, Ni, Co. *Soluble in Water*.—Acetates, chlorides, nitrates, sulphates, of all. Fe, Al, Ni, Co; citrates. Fe(ic), Cr, Al, Co; tartrates. Fe(ous); iodide. Fe(ic); ferricyanide, hypophosphite,* pyrophosphate (in “scale preparations”). Zn; chloride, iodide, valerianate. Cr; chromates and dichromates of alkalies. Mn; manganates and permanganates of alkalies.

Insoluble in Water, Soluble in Acids.—Arsenates, carbonates, hydroxides, oxides, phosphates, sulphides, of all. Fe(ous) tartrate. Zn, phosphide.

Insoluble in Water and Acids.—Fe; ferrocyanide. Fe(ous); ferricyanide. Cr; oxide.† Al; oxide,† silicate.†

GROUP IV. Ca, Ba, Sr, Mg. *Soluble in Water*.—Acetates, bromides, chlorates, chlorides, iodides, nitrates, of all. Ba, Sr, Ca; hydroxides,* oxides,* sulphides. Ca; chromate,* citrate,* hypophosphite, sulphate.* Mg; chromate, citrate, sulphate.

Insoluble in Water, Soluble in Acids.—Ba, Ca, Sr; carbonates, oxalates, phosphates. Mg; carbonate.* Br, Sr; chromates, sulphites. Mg; hydroxide,* oxide.* Ba; dioxide (with decomposition).

Insoluble in Water and Acids.—Ba, Sr; sulphates.*

GROUP V. K, Na, Li, NH₄. *Soluble in Water*.—Li; benzoate, bicarbonate, bromide, chloride, oxide, salicylate, sulphate. K, Na; acetates, arsenates, arsenites, bicarbonates, bisulphites, borates, carbonates, chlorates, cyanides, hydroxides, hypochlorites, hypophosphites, iodides, nitrates, nitrites, oxides, phosphates, pyrophosphates, silicates, sulphates, sulphides, sulphites, thiosulphates (hyposulphite of U. S. P.), NH₄; bromide, carbonate, chloride, iodide, nitrate, sulphate, sulphide.

(Note.—All common salts of alkalies, except those named below, are soluble in water.)

Insoluble in Water, Soluble in Acids.—K, NH₄; acid tartrates,* platinic chlorides.* K; perchlorate.* Na; antimonate. Li; carbonate, phosphate.*

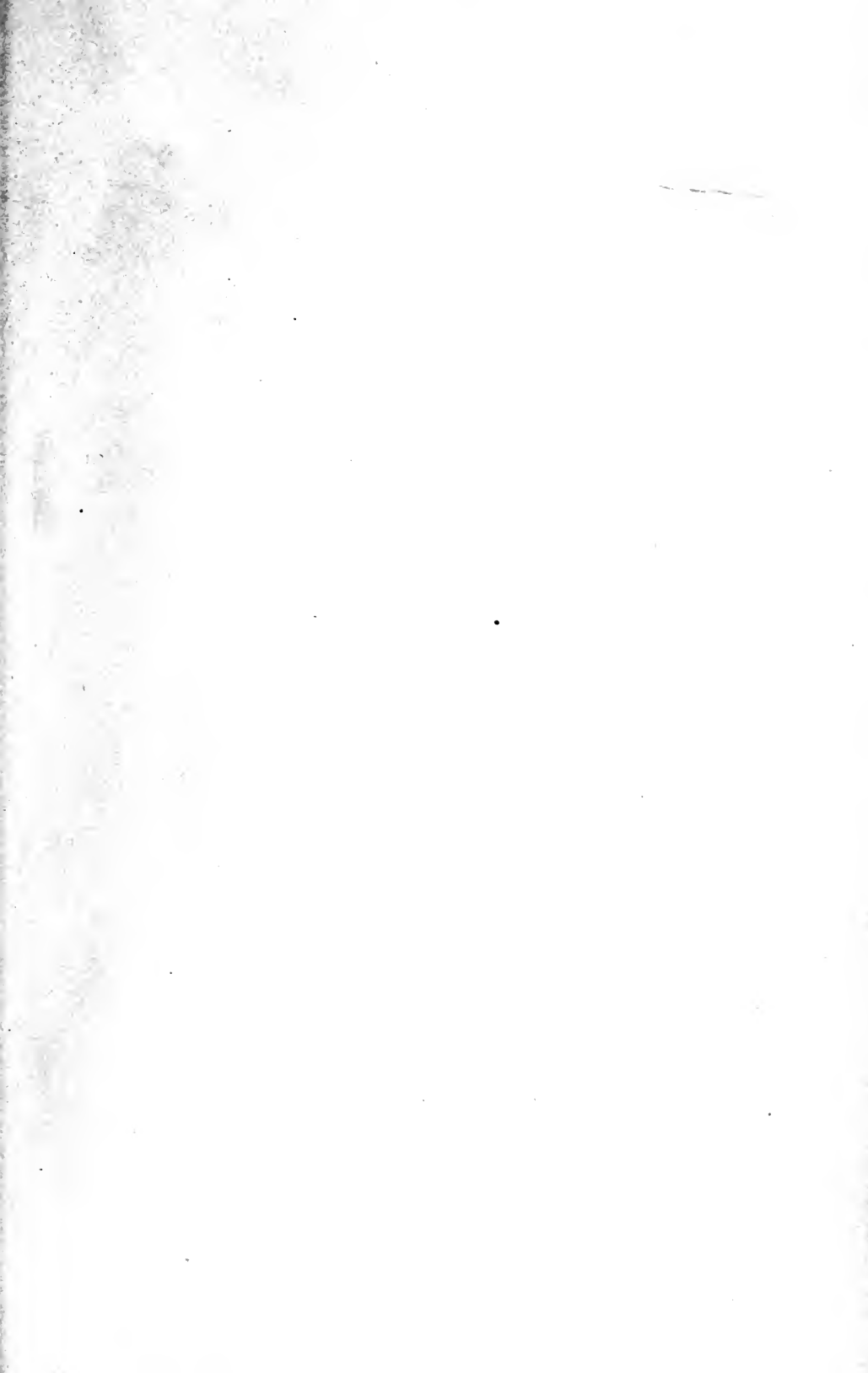
* Sparingly soluble in water.

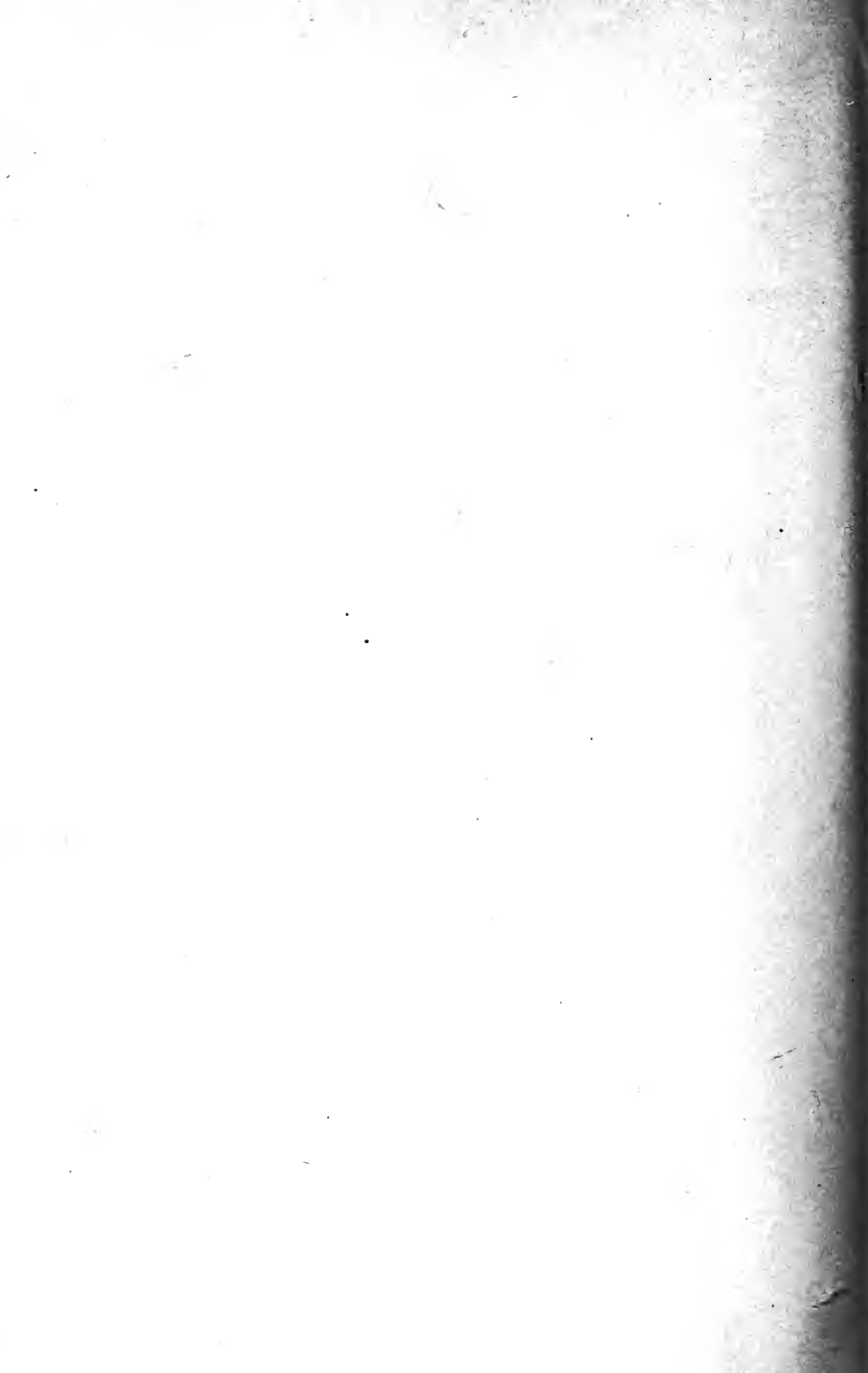
† Sparingly soluble in acids.

LIST OF REAGENTS.*

- Acid, Acetic, $\text{HC}_2\text{H}_3\text{O}_2$. Sp. gr. 1.04, 30 p. c.; U. S. P. acid, strong, sp. gr. 1.048, 36 p. c.; U. S. P. dilute, sp. gr. 1.008, 6 p. c. Glacial Acetic Acid, 99.5 p. c.
- “ Hydrochloric, HCl . U. S. P. strong, sp. gr. 1.16, 31.9 p. c.; U. S. P. dil., sp. gr. 1.05, 10 p. c.
- “ Hydrosulphuric, H_2S . A gas, by action of FeS on HCl .
- “ Nitric, HNO_3 . Sp. gr. 1.24, 32 p. c.; U. S. P. strong, sp. gr. 1.414, 68 p. c.; U. S. P. dil., sp. gr. 1.057, 10 p. c. “Yellow Nitric” acid, called also Nitrous Acid, contains NO_2 in solution.
- “ Nitrohydrochloric, $\text{NOCl} + \text{Cl}_2$. 180 c.c. U. S. P. strong HNO_3 with 820 c.c. strong HCl .
- “ Oxalic, $\text{H}_2\text{C}_2\text{O}_4$. 1 part crystals in 10 parts water (1-10).
- “ Phosphoric, H_3PO_4 . U. S. P. strong, sp. gr. 1.71, 85 p. c.; U. S. P. dil., sp. gr. 1.057, 10 p. c.
- “ Picric, $\text{C}_6\text{H}_2(\text{NO}_3)_3\text{OH}$. Saturated aqueous solution.
- “ Salicylic, $\text{HC}_7\text{H}_5\text{O}_3$. Solid or in aqueous solution.
- “ Sulphuric, H_2SO_4 . U. S. P. strong, sp. gr. 1.835, 92.5 p. c.; U. S. P. dil., sp. gr. 1.070, 10 p. c.
- “ Tannic, $\text{C}_{14}\text{H}_{10}\text{O}_9$. 4 parts in 100 parts of hot water.
- “ Tartaric, $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$. (1-3.)
- “ Trichloroacetic, $\text{HC}_2\text{Cl}_3\text{O}_2$. Solid.
- Acidulated Brine. 500 c.c. of saturated NaCl solution, 30 c.c. HCl .
- Alcohol, $\text{C}_2\text{H}_5\text{OH}$. *Absolute*. Not less than 99 p. c. by weight. Place ordinary alcohol in a flask with quick lime, and after standing several days distil off at as low a temperature as possible.
- Alcohol. *Ordinary*. About 91 p. c. by weight.
- Almen's Reagent. (Nylander's.) BiONO_3 , 2 grammes; $\text{NaKC}_4\text{H}_4\text{O}_6$, 4 grammes; NaOH , 8 grammes; water, 100 c.c.
- Ammonio-Cupric Sulphate. To solution of copper sulphate add ammonium hydroxide until the precipitate first formed *just* redissolves.
- Ammonio-Silver Nitrate. To solution of silver nitrate add ammonium hydroxide until the precipitate first formed *just* redissolves.

* Certain special reagents will be found described in the text with the tests in which they are used.





Ammonium Carbonate, $(\text{NH}_4)_2\text{CO}_3$. (1-4.)

“ Chloride, NH_4Cl . (1-8.)

“ Hydroxide, NH_4OH . Sp. gr. 0.96, 10 p. c. NH_3 .
“Stronger Ammonia,” sp. gr. 0.901, 28 p. c.

“ Molybdate, $(\text{NH}_4)_2\text{MoO}_4$. 10 grammes dissolved
in 67 c.c. of hot water, with addition of a little
ammonium hydroxide if necessary, added grad-
ually to a mixture of 33 c.c. nitric acid (sp. gr.
1.414) with 34 c.c. water.

“ Oxalate, $(\text{NH}_4)_2\text{C}_2\text{O}_4$. (1-24.)

“ Sulphate, $(\text{NH}_4)_2\text{SO}_4$. Saturated aqueous solu-
tion.

“ Sulphydrate, NH_4HS . Ammonium hydroxide
saturated with hydrosulphuric acid.

“ Sulphide, $(\text{NH}_4)_2\text{S}$. Add $\frac{2}{3}$ volume of ammonium
hydroxide to one volume of sulphydrate.

Barfoed's Reagent. Dissolve 10 grammes of pure copper ace-
tate in 150 c.c. water, and add 4.5 c.c. U. S. P. acetic acid.

Barium Carbonate, BaCO_3 . Solid, or saturated solution.

“ Chloride, BaCl_2 . (1-10.)

“ Hydroxide, $\text{Ba}(\text{OH})_2$. Saturated aqueous solution.

“ Mixture. Two volumes of saturated solution of barium
hydroxide with one volume of saturated solution of
barium chloride.

“ Nitrate, $\text{Ba}(\text{NO}_3)_2$. (1-10.)

Bismuth Subnitrate, BiONO_3 (?). Solid.

Bleaching Powder, CaOCl_2 .

Boas' Reagent. Pure resorcin, 5 grammes; Cane sugar, 3
grammes; dilute alcohol, 100 c.c.

Bromine Water, Br. Aqueous solution of bromine.

Calcium Chloride, CaCl_2 . (1-8.)

“ Hydroxide, $\text{Ca}(\text{OH})_2$. Saturated aqueous solution.

Carbol-Fuchsin, see p. 125.

Carbon Dioxide, CO_2 . By action of HCl on CaCO_3 .

“ Disulphide, CS_2 . Pure.

Chlorine Water, Cl. Aqueous solution of chlorine.

Chlorinated Soda, for Urea Test. 25 c.c. solution of chlorinated
soda; 5 c.c. potassium bromide (20 p. c.).

Chloroform, CHCl_3 . Sp. gr. about 1.49 at 15°C . Boils at
 60°C .

Cochineal. (Indicator.) Macerate 1 gramme for several days with 20 c.c. alcohol and 60 c.c. water. Filter.

Collodion. 30 grammes of pyroxylin in ether 750 c.c. and alcohol 250 c.c.

Congo-red Paper. Prepared by soaking unsized paper in 1 p. c. aqueous solution of Congo-red.

Copper Sulphate, CuSO_4 . (1-8.)

Cupric Ammonium Hydroxide. Solution of $\text{Cu}(\text{OH})_2$ in ammonia.

Esbach's Reagent. Picric Acid, 10 grammes; Citric Acid, 20 grammes; Water to 1000 c.c.

Ether, $(\text{C}_2\text{H}_5)_2\text{O}$. Sp. gr. about 0.727 at 15°C . Boils at 37°C .

Fehling's Solution. Prepared in 2 parts. I. 34.639 grammes of pure crystallized CuSO_4 , dissolved in water and diluted to 500 c.c. II. 173 grammes Rochelle salts and 60 grammes NaOH , dissolved in water and diluted to 500 c.c. For use mix equal volumes of I. and II. Ten c.c. of the mixed solution = 0.05 gramme glucose. For use, 1 part of the mixed solution is diluted with about 3 parts water.

Ferric Chloride, Fe_2Cl_6 . (1-15.) Neutral Ferric Chloride may be made by adding *dilute* ammonium hydroxide until a *faint* precipitate is obtained. Filter and use filtrate.

Ferrous Sulphate, FeSO_4 . (1-10.)

Fröhde's Reagent. 0.1 gramme of sodium molybdate in 10 c.c. of conc. sulphuric acid.

Gastric Juice, Artificial. Add 0.3 gramme of pepsin to 100 c.c. of 0.3 p. c. hydrochloric acid.

Gold Chloride, AuCl_3 . (1-30.)

Guaiac Mixture. 0.5 gramme gum guaiac in 10 c.c. alcohol with a few drops of copper sulphate (1-2000.).

Gunzberg's Reagent. Phloroglucin, 2 pts.; Vanillin, 1 pt.; Absolute Alcohol, 30 pts., by weight.

Haines' Solution. Dissolve 2 grammes pure CuSO_4 (crys.) in 15 c.c. of water, add 15 c.c. of pure glycerol and then 150 c.c. of 5 p. c. KOH solution. A clear dark blue liquid should result.

Indigo-Carmine Solution. 1 gramme commercial indigo-carmine in 150 c.c. of water.

Iodine Test Solution. 1 gramme iodine, 3 grammes potassium iodide, in 50 c.c. water.

Lead Acetate, $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$. (1-10.)



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8

Litmus Test Solution. Exhaust powdered litmus with boiling alcohol. Digest residue in cold water, filter, and extract residue with boiling water. Filter and preserve the filtrate as a test solution. *Litmus paper* is prepared by impregnating unsized paper with the above solution.

Magnesium Chloride, MgCl_2 . (1-10.)

“ Mixture, 1 pt. cryst. MgCl_2 ; 2.5 pts. NH_4Cl ; 5 pts. NH_4OH , and 10 pts. water. Let stand, then filter.

“ Sulphate, MgSO_4 . Saturated aqueous solution.

Mayer's Solution. 13.546 grammes HgCl_2 dissolved in 600 c.c. of water. 49.8 grammes KI dissolved in 100 c.c. of water. Mix and dilute to 1000 c.c.

Mercuric Chloride, HgCl_2 . (1-20.)

Mercurous Nitrate, $\text{Hg}_2(\text{NO}_3)_2$. (1-20.) Acidulate with nitric acid.

Methylene Blue, see p. 125.

Methylene Blue and Eosin, see p. 93.

Methyl Orange. (Tropæolin D.) 1 gramme in 1000 c.c. of water. Add dilute sulphuric acid drop by drop, until liquid just turns red. Filter.

Millon's Reagent. 1 pt. mercury treated with 2 pts. HNO_3 in the cold. Then heat on water bath, dilute with 2 pts. water, and after several hours, decant the clear liquid.

Nessler's Reagent. See page 146.

Nylander's Reagent. See Almen's Reagent.

Pavy's Solution. Copper sulphate, 3.465 grammes; Rochelle salt, 17 grammes; potassium hydroxide, 17 grammes. Dissolve in distilled water and make solution up to 100 c.c. Add 333 c.c. ammonium hydroxide, sp. gr. 0.88, and 396 c.c. water. For the test, use, undiluted, 50 c.c. of the solution. This will be reduced by 0.025 gramme of glucose.

Phenolphthalein. (Indicator.) 1 gramme in 100 c.c. dil. alcohol.

Platinic Chloride, PtCl_4 . (1-10.)

Potassium Carbonate, K_2CO_3 . (1-20.)

“ Chlorate, KClO_3 . Solid.

“ Chromate, K_2CrO_4 . (1-10.)

“ Dichromate, $\text{K}_2\text{Cr}_2\text{O}_7$. (1-10.)

“ Ferricyanide, $\text{K}_3\text{Fe}(\text{CN})_6$. (1-12.)

Potassium Ferrocyanide, $K_4Fe(CN)_6$. (1-12.)

“ Hydroxide, KOH. (1-9.)

“ Iodide, KI. (1-20.)

“ Nitrate, KNO_3 . Solid.

“ Sulphate, K_2SO_4 . (1-12.)

Potassium Sulphocyanate, KCNS. (1-12.)

Purdy's Solution. $CuSO_4$, 4.742 grammes; glycerol, 38 c.c.; KOH, 23.5 grammes. Ammonium hydroxide, sp. gr. 0.9, 450 c.c. Water to 1000 c.c. 35 c.c. of this solution are reduced by 0.02 grammes of glucose.

Schiff's Reagent. An aqueous solution of magenta (rosaniline-hydrochloride) decolorized by sulphur dioxide.

Silver Nitrate, $AgNO_3$. (1-30.)

Sodium Acetate, $NaC_2H_3O_2$. (1-5.)

“ Carbonate, Na_2CO_3 . (1-5) or solid.

“ Chloride, NaCl. Solution.

“ Hydroxide, NaOH. (1-9.)

“ Hydroxide, Alcoholic. Solution of NaOH in dilute alcohol.

“ Hypobromite, NaBrO, for Urea test. 100 grammes NaOH in 250 c.c. water, with 25 c.c. bromine added.

“ Hypochlorite, NaClO, for Urea test. See Chlorinated Soda.

“ Nitroprusside, $Na_2FeNO(CN)_6$. Aqueous solution.

Stannous Chloride, $SnCl_2$. (1-6.) Aqueous solution.

Strontium Nitrate, $Sr(NO_3)_2$. Aqueous solution.

Sulphuretted Hydrogen. See Hydrosulphuric Acid.

Tanret's Solution. $HgCl_2$, 1.35 grammes; KI, 3.32 grammes; Acetic acid, 20 c.c. Distilled water to 100 c.c.

Uffelmann's Reagent. To 10 c.c. of 1 p. c. Phenol add 2 drops of aqueous Ferric Chloride solution. Solution should be freshly prepared.

Uranium Nitrate, Standard Solution. See page 116.



POISONS, AND THE TREATMENT OF POISONING.

GENERAL PRINCIPLES OF TREATMENT.

1. *Remove the poison from the stomach.* Wash out the stomach, using a stomach tube, or give emetics, *e. g.*, *zinc sulphate*, *mustard*, *ipécacuanha*, or, hypodermically, *apomorphine*. Follow with purgatives, *e. g.*, *magnesium sulphate*, *castor oil*, etc.

2. *Administer the chemical antidote.* In poisoning by acids, give *magnesia* in water or milk. In poisoning by alkalies, give dilute *acetic acid*, or vinegar, dilute *citric acid*, or lemon juice. In poisoning by alkaloids, give a solution of *tannin*, or strong tea. The chemical antidote may advantageously be mixed with the water used in washing the stomach. When possible administer the *special* chemical antidote.

3. *Administer the physiological antidote.* (a) When the pulse is weak, intermittent, or slow, sustain the heart by subcutaneous injections of *nitroglycerin*, or *atropin*, or give an enema of *brandy* or of strong coffee. Keep the patient in a recumbent position.

(b) When the respiration is difficult, keep the *body warm*, apply *cold affusions* to the head, perform *artificial respiration*, resort to *tracheotomy* if necessary.

(c) When there is coma or insensibility, apply *friction*, flagellation, mustard plasters, or administer excitants, *e. g.*, *strychnine*. Forced walking may be resorted to, but not when the heart is affected.

(d) When there are convulsions, spasms, etc., administer *ether* or *chloroform* by inhalation, give *potassium bromide*, or, subcutaneously, *morphine*. Chloral is not advised. Valerian may be given per rectum.

DOSAGE OF REMEDIES USED.

ACETIC ACID. (36 per cent. U. S. P.) Dilute one part with 6 or 7 parts of water.

AMYL NITRITE. For inhalation. 2–4 minims. (0.12–0.24 c.c.)
 APOMORPHINE HYDROCHLORATE. Hypodermically, $\frac{1}{10}$ grain.
 (0.00648 gramme.)

ATROPINE SULPHATE. Hypodermically, $\frac{1}{120}$ grain. (0.00054 gramme.)

BRANDY. Hypodermic dose, 20–30 minims. (1.23–1.84 c.c.)

CHLORAL. 10–20 grains. (0.65–1.3 grammes.)

COPPER SULPHATE. 10–30 grains. (0.65–2.0 grammes.)

ETHER. For inhalation.

IPECACUANHA. As an emetic, 20 grains in water. (1.3 grammes.)

MAGNESIA. Give freely, suspended in water or milk.

MAGNESIUM SULPHATE. Dose about one ounce. (31 grammes.)

MORPHINE SULPHATE. Hypodermic dose, $\frac{1}{4}$ grain. (0.0162 gramme.)

NITROGLYCERIN. Hypodermic dose, $\frac{1}{100}$ grain. (0.000648 gramme.)

POTASSIUM BROMIDE. 10–30 grains, (0.65–2.0 grammes.)

STRYCHNINE SULPHATE. Hypodermic dose, $\frac{1}{80}$ grain. (0.00108 gramme.)

TANNIC ACID (Tannin). 10–20 grains. (0.65–1.30 grammes.)

ZINC SULPHATE. 10–30 grains. (0.65–2.0 grammes.)

Other, special, remedies are given in the list of poisons which follows.

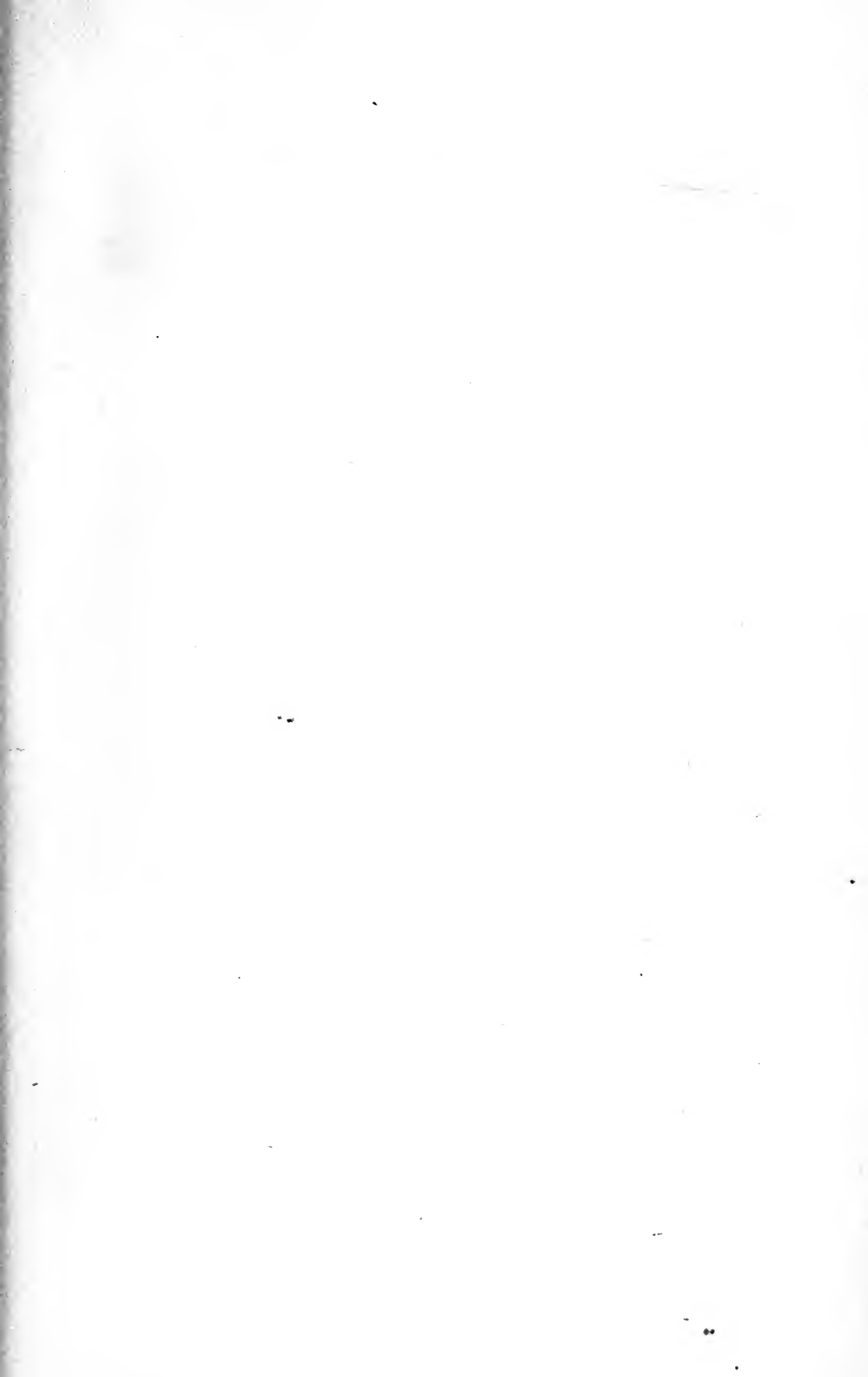
POISONS, WITH TREATMENT.

ACIDS. (Concentrated.) Violent pain, vomiting, retching, hæmatemesis, prostration, collapse, possibly asphyxia. *Treatment*.—Magnesia in water or milk, flour in milk, demulcent drinks, morphine to allay pain. Hypodermic stimulants in collapse, food per rectum.

ACIDS. (Dilute.) Similar to concentrated acids, less corrosion, more true inflammation. *Treatment*.—Stomach tube, emetics, magnesia in milk, barley water, etc.

ACONITINE. Numbness, tingling, deafness, dimness of vision, paralysis, heart and respiration depressed. *Treatment*.—Stomach tube, emetics, nitroglycerin or strychnine hypodermically, brandy enema, inhalation of amyl nitrite, recumbent position, warmth to body.

ALCOHOL. (Spirits, etc.) Acute poisoning. Dyspnoea, dilated pupils, convulsions, stupor, coma. *Treatment*.—Stomach tube,





emetics, cold affusion to head, inhalation of amyl nitrite, strong coffee, fresh air, warmth to body.

ALKALIES. (*Caustic, concentrated.*) Similar to concentrated acids, q. v. (Test reaction of vomited matter.) *Treatment.*—Gruel, barley water, emetics, morphine to allay pain, hypodermic stimulants, food per rectum.

ALKALIES. (*Dilute.*) Similar to dilute acid, q. v. *Treatment.*—Stomach tube, emetics, dilute acetic acid, vinegar, lemon juice, demulcent drinks.

ALUM. In large doses an irritant. *Treatment.*—Stomach tube, emetics, magnesia, weak solution of ammonium carbonate.

AMMONIA. The fumes cause laryngeal spasms, coughing, etc. *Treatment.*—Inhalation of acetic acid vapors, or of chloroform. Otherwise ammonia is similar to other Alkalies, q. v.

AMYL NITRITE. Heart poison. *Treatment.*—Fresh air, strychnine or atropine hypodermically, picrotoxin, recumbent position.

ANTIMONY. (Tartar emetic.) Nausea, retching, vomiting, pain, purging, general depression. *Treatment.*—Stomach tube if necessary, solution of tannin or strong tea, white of eggs, in collapse strychnine hypodermically, brandy enema, keep body warm.

ANTIMONY CHLORIDE. Similar to acids, q. v.

ARNICA. An irritant. *Treatment.*—Emetics, alcoholic stimulants, etc.

ARSENIC. Thirst, burning pain, vomiting, purging, cramps, skin cold, pulse small. *Treatment.*—Stomach tube, emetics, milk with white of egg, magnesium sulphate, magnesia. Keep body warm, and, if necessary, relieves pain with morphine. *Special antidote:* Freshly precipitated ferric hydroxide. Add ammonium hydroxide (or sodium carbonate) to an aqueous solution of ferric chloride, filter through a handkerchief, wash with water, and administer in teaspoonful doses.

ATROPINE. (Belladonna.) Face flushed, pupils dilated, eyes prominent, contraction of pharynx, excitement, delirium. *Treatment.*—Emetics, pilocarpin nitrate ($\frac{1}{4}$ – $\frac{1}{2}$ grain), morphine, coffee enema. Hot bags at feet, and if necessary, artificial respiration.

BIARIUM SALTS. Irritants, pain, vomiting, etc. *Treatment.*—Stomach tube, emetics, magnesium sulphate, sodium sulphate, mucilaginous drinks.

BELLADONNA. See Atropine.

BICHLORIDE OF MERCURY. See Mercury.

BROMINE. Spasmodic action of larynx and pharynx, burning pain, tremor, and collapse. *Treatment*.—As under Iodine, q. v.

BRUCINE. Similar to Strychnine, q. v.

CALABAR BEAN. See Physostigmine.

CAMPHOR. In large doses a cerebral poison. *Treatment*.—Stomach tube, emetics, brandy hypodermically or as an enema. Keep body warm.

CANTHARIDIN. Blisters, burning pain, dull pain in loins, urine bloody, genito-urinary inflammation. *Treatment*.—Stomach tube, apomorphine, magnesium sulphate, morphine, stimulants. When powder has been taken give gum arabic and water.

CARBOLIC ACID. (Phenol.) Faintness, palor or lividity, pupils contracted, feeble pulse, stertorous breathing, coma, urine darkens on exposure, odor of breath. *Treatment*.—Stomach tube to be used very cautiously. Zinc sulphate, sodium sulphate, or magnesium sulphate, white of eggs, atropine, brandy, inhalation of amyl nitrite, dilute acetic acid or diluted vinegar, keep body warm.

CASTOR SEEDS. Purging, thirst, convulsions. *Treatment*.—Tannin or strong tea, morphine for the pain, keep extremities warm, and give stimulants.

CHLORAL. Local irritant, heart depressed, coma. *Treatment*.—Stomach tube, emetics, atropine, or strychnine, brandy or coffee enema, amyl nitrite, artificial respiration if necessary, body warm.

CHLOROFORM. (*Inhaled*.) *Treatment*.—Artificial respiration, oxygen, cold affusions, galvanism, stimulants, amyl nitrite, strychnine.

CHLOROFORM. (*Internal*.) Burning pain, possibly vomiting, insensibility, weak pulse, dilated pupils, stertorous breathing. *Treatment*.—Stomach tube, emetics, enema of coffee, amyl nitrite, artificial respiration.

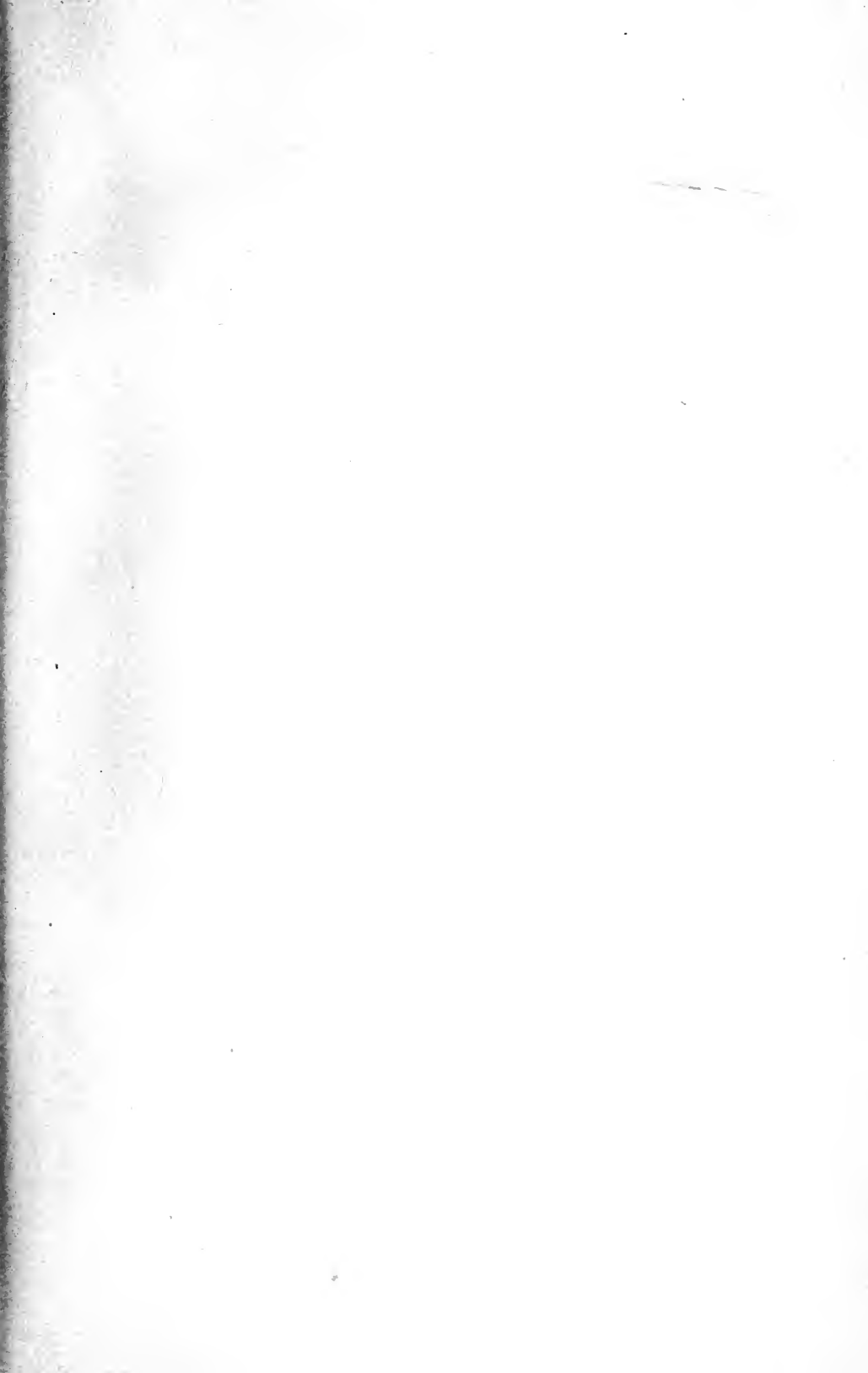
CHROMIUM SALTS. Vomiting, diarrhœa, etc. *Treatment*.—Stomach tube, emetics, magnesia, barley water, etc.

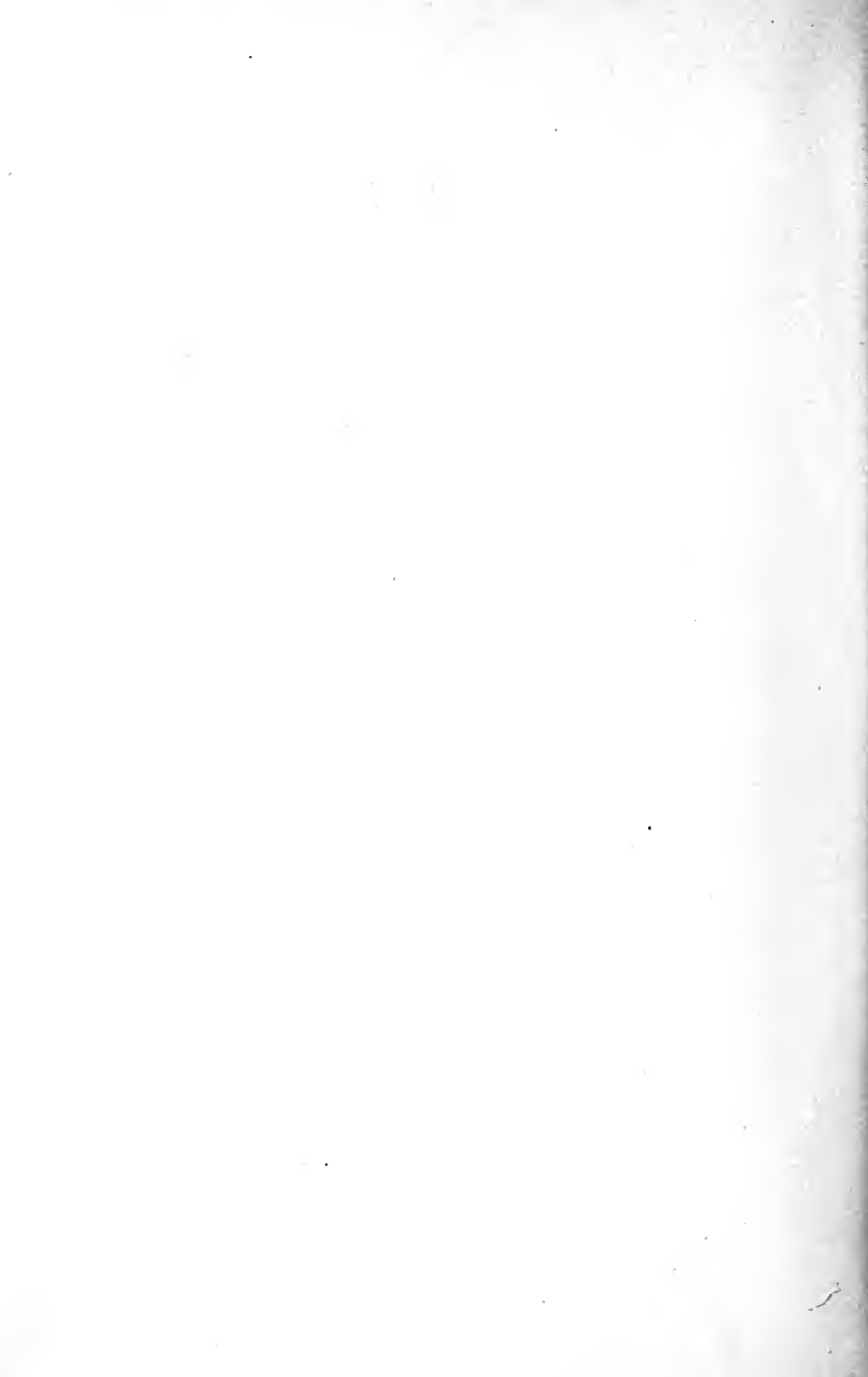
COCAINE. Faintness, dizziness, weak pulse, delirium or coma, sometimes paralysis. *Treatment*.—Stomach tube, emetics, fresh air.

COCCULUS INDICUS. Nausea, debility, possibly convulsions. *Treatment*.—Stomach tube, emetics, chloral, potassium bromide.

COLCHICUM. Thirst, vomiting, purging, exhaustion, cramps. *Treatment*.—Stomach tube, tannin or tea, water, body warm, stimulants.

COLOCYNTH. Similar to colchicum, q. v.





CONIUM. (Hemlock.) Weakness, staggering, paralysis. *Treatment*.—Stomach tube, apomorphine, tannin, strychnine, stimulants.

COPPER SALTS. Vomiting, purging, pain. *Treatment*.—Apomorphine if necessary, warm milk with white of egg, magnesia, potassium ferrocyanide.

CORROSIVE SUBLIMATE. See Mercury.

CREOSOTE. See Carbolic Acid.

CROTON OIL. Intense pain, vomiting, purging, collapse. *Treatment*.—Wash with stomach tube, demulcent drinks, morphine, brandy, stimulants, camphor spirits 10 drops on sugar every ten minutes, keep body warm.

CYANIDES. Similar to Prussic acid, q. v.

DIGITALIN. In large doses, pain, vomiting, "blue vision," headache, vertigo, paralysis of heart. *Treatment*.—Emetics, tannin, morphine, aconitine ($\frac{1}{300}$ grain), senega (15 grains), recumbent position.

ERGOT. In large doses acts as irritant, and, indirectly, on heart. *Treatment*.—Zinc sulphate as emetic, tannin, tea, nitroglycerin, aconitine ($\frac{1}{300}$ grain), friction, keep body warm.

ETHER. Internally acts as an irritant and produces intoxication. Inhaled is similar to chloroform, though not so depressing. *Treatment*.—See Chloroform.

FORMALDEHYDE. (Formalin.) Vomiting, pain. *Treatment*.—White of egg, stomach tube, emetics.

FUSEL OIL. (Amyl alcohol.) Headache, nausea, prostration, coma. *Treatment*.—See Alcohol.

GASES. (Asphyxia.) Loss of muscular power, insensibility, labored breathing. *Treatment*.—Artificial respiration, fresh air, oxygen, ozone, friction, brandy hypodermically or as an enema.

GELSEMIUM. (Gelsemine.) Pain in eyes, disturbed vision, weakness, pain in chest, difficult respiration. *Treatment*.—Stomach tube, emetics, electricity, atropine, nitroglycerin, artificial respiration.

HEMLOCK. (Conium maculatum. See Conium.) Circuta maculata (the Water Hemlock), vomiting, pain, violent convulsions. *Treatment*.—Emetics, chloral, chloroform, etc.

HYDROCHLORIC ACID. See Acids.

HYDROCYANIC ACID. See Prussic Acid.

HYOSCYAMINE. Similar to Atropine, q. v.

IODINE. Pain, vomiting, purging, full rapid pulse, eruptions on

skin. *Treatment*.—Emetics, starch and water, flour and water, amyl nitrite, morphine for pain.

IODIDES. Often produce catarrhal symptoms, voice reduced, little pain. Otherwise similar to Iodine. *Treatment*.—Stomach tube, emetics, atropine.

ODOFORM. Anorexia, depression or excitement, rapid pulse, high temperature, collapse. *Treatment*.—Remove cause, and treat symptoms.

JABORANDI. See Pilocarpine.

LAUDANUM. See Morphine.

LEAD SALTS. (*Acute*.) Nausea, burning in stomach, colic, retching. *Treatment*.—Stomach tube and emetics. Magnesium sulphate, sodium sulphate, potassium iodide.

(*Chronic*.) Anæmia, fetid breath, colic, constipation, "wrist drop," palsy. *Treatment*.—Remove cause and nourish.

LOBELIA. Motor depressant, narcotic, emetic. *Treatment*.—Stomach tube, brandy, atropine, strychnine.

MERCURY. (Corrosive Sublimate.) Painful constriction of throat, burning pain, purging, evacuations show mucus and blood, cold perspiration, faintness, convulsions. *Treatment*.—Promote vomiting, white of egg in milk, followed by stomach tube, magnesia, alkaline carbonates, morphine for pain.

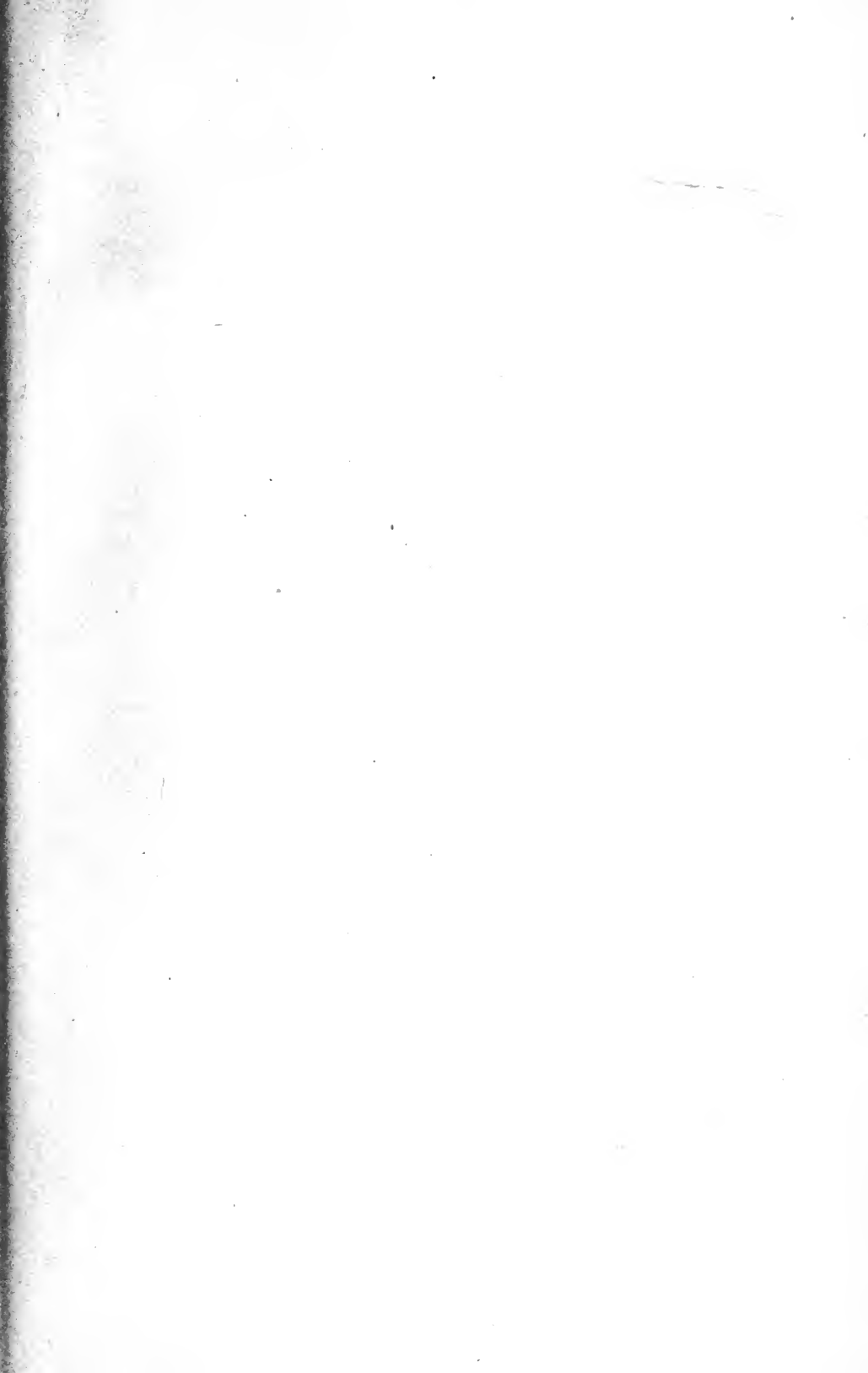
MORPHINE. (Opium, etc.) Brief excitement, then weight in limbs, drowsiness, sleep, coma, pupils contracted, labored breathing, feeble pulse, skin generally warm, muscles flabby in bad cases. *Treatment*.—Stomach tube, emetics, atropine, potassium permanganate (10 grains in water), coffee as enema, keep body warm, amyl nitrite inhalations, cold affusions, faradization.

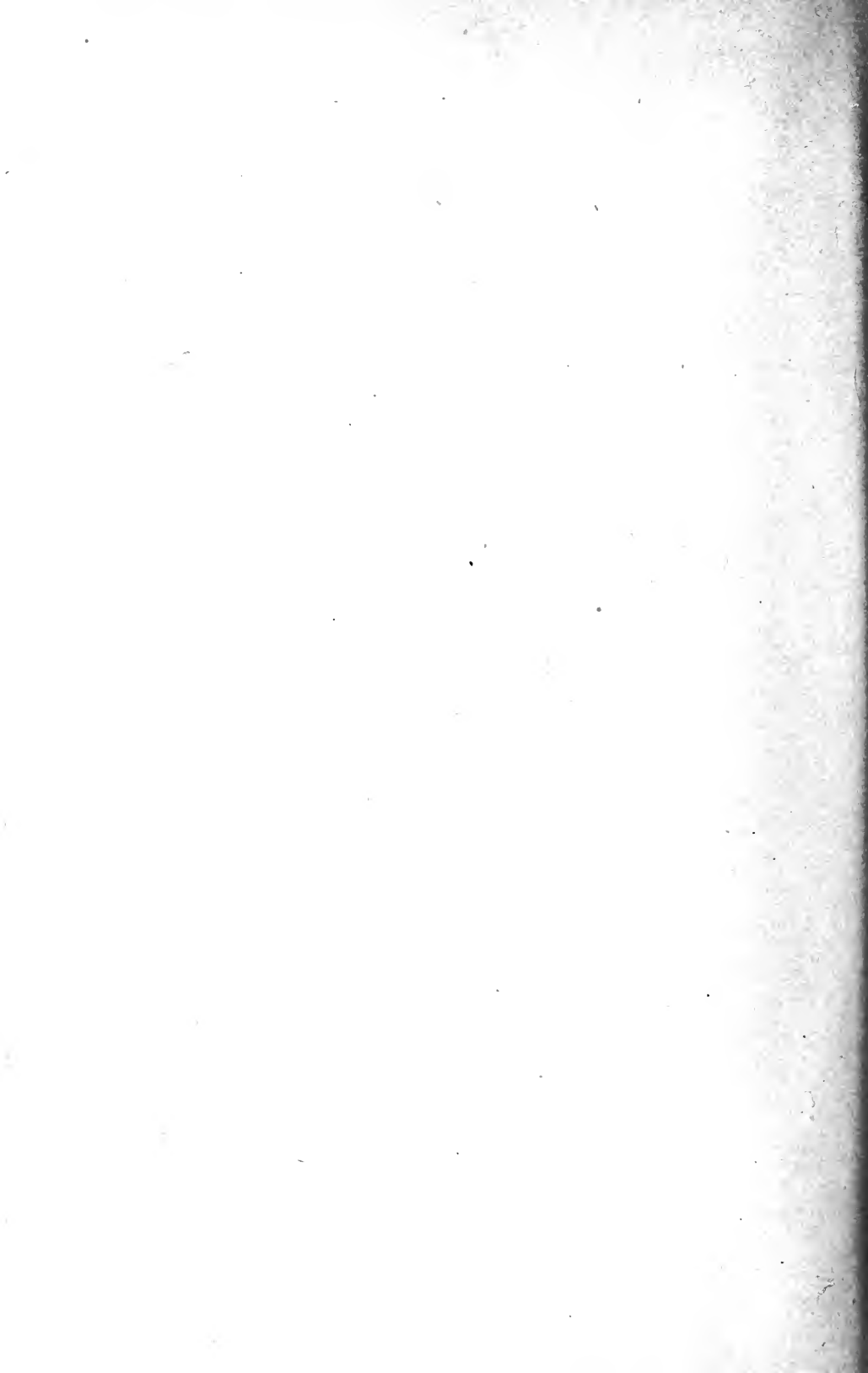
MUSHROOMS. (Poisonous Fungi.) *Amanita muscaria* (Fly fungus). Heart's action retarded, difficult breathing, stupor, cold sweat, convulsions. *Treatment*.—Stomach tube, emetics, castor oil, atropine ($\frac{1}{16}$ to $\frac{1}{8}$ grain), stimulants and warmth.

Amanita phalloides. (Death Cup.) Pain, nausea, vomiting, purging, otherwise similar to *A. muscaria*. *Treatment*.—Rarely satisfactory, stimulants, etc., physiological salt solution subcutaneously may help.

NICOTINE. (Tobacco.) Acts on heart and respiratory centers. *Treatment*.—Emetics if necessary, tannin, brandy, strychnine, recumbent position and warmth.

NITROBENZENE. Similar to Prussic acid, but with more nausea. *Treatment*.—Same as for Prussic acid.





NUX VOMICA. See Strychnine.

OPIUM. See Morphine.

OXALIC ACID. Similar to Acids, *q. v.*, with addition of depression of heart, and other neurotic symptoms. *Treatment.*—As for Acids, lime water is excellent, do not use salts of alkalies.

PHENOL. See Carbolic acid.

PHOSPHORUS. Disagreeable taste, thirst, nausea, vomiting, purging, later a jaundiced condition and hemorrhages, sometimes neurotic symptoms, cramps, convulsions. *Treatment.*—Copper sulphate, magnesia in mucilaginous drinks, magnesium sulphate, animal charcoal, inhalation of oxygen or ozone. Old oil of turpentine.

PHYSOSTIGMINE. (Calabar bean.) Prostration, paralysis of lower limbs, pupils contracted, asphyxia. *Treatment.*—Emetics, tannin, atropine, strychnine, artificial respiration.

PICROTOXIN. (Cocculus Indicus.) Nausea, debility, may be convulsions. *Treatment.*—Remove poison, potassium bromide, chloral.

PILOCARPINE. Profuse secretions, temperature low, heart quickened, paralysis of heart. *Treatment.*—Emetics, tannin, atropine, warmth.

POTASH. (Caustic.) See alkalies.

POTASSIUM CHLORATE. Vomiting, diarrhoea, hemoglobinuria. *Treatment.*—Same as for Potassium nitrate.

POTASSIUM CYANIDE. Similar to Prussic acid, *q. v.*

POTASSIUM NITRATE. (Nitre.) Pain, vomiting, possibly convulsions, or paralysis. *Treatment.*—Stomach tube, apomorphine, water, amyl nitrite.

PRUSSIC ACID. (Hydrocyanic acid.) Vertigo, loss of muscular power, loss of consciousness, eyes fixed, pupils large, skin cold, convulsive breathing. *Treatment.*—Stomach tube, emetics, atropine, brandy, body warm, cold affusions to neck, artificial respiration.

SILVER NITRATE. (Lunar caustic.) An irritant. *Treatment.*—Stomach tube, emetics, sodium chloride freely in water.

SODA. (Caustic.) See Alkalies.

SOLANIN. Similar to Atropine, *q. v.*

SNAKE POISONS. Local irritants, with heart and respiratory symptoms. *Treatment.*—Suck wound, ligature, wash with solution of permanganate, or, better, with a fresh solution of calcium hypo-

chlorite, inject hypochlorite around wound. The hypochlorite solution is made by dissolving one part dry hypochlorite of lime in eleven parts of water. Hypodermic dose, 1-2 c.c., with a total of 20 c.c.

STRAMONIUM. Similar to Atropine, *q. v.*

STRYCHNINE. Restlessness, shuddering, twitching, then tetanic convulsions generally with opisthotonos, followed by periods of relaxation. *Treatment.*—Emetics, tannin, inhalation of ether, potassium bromide, nitroglycerin. Keep patient in darkened room and avoid excitement.

SULPHURIC ACID. See Acids.

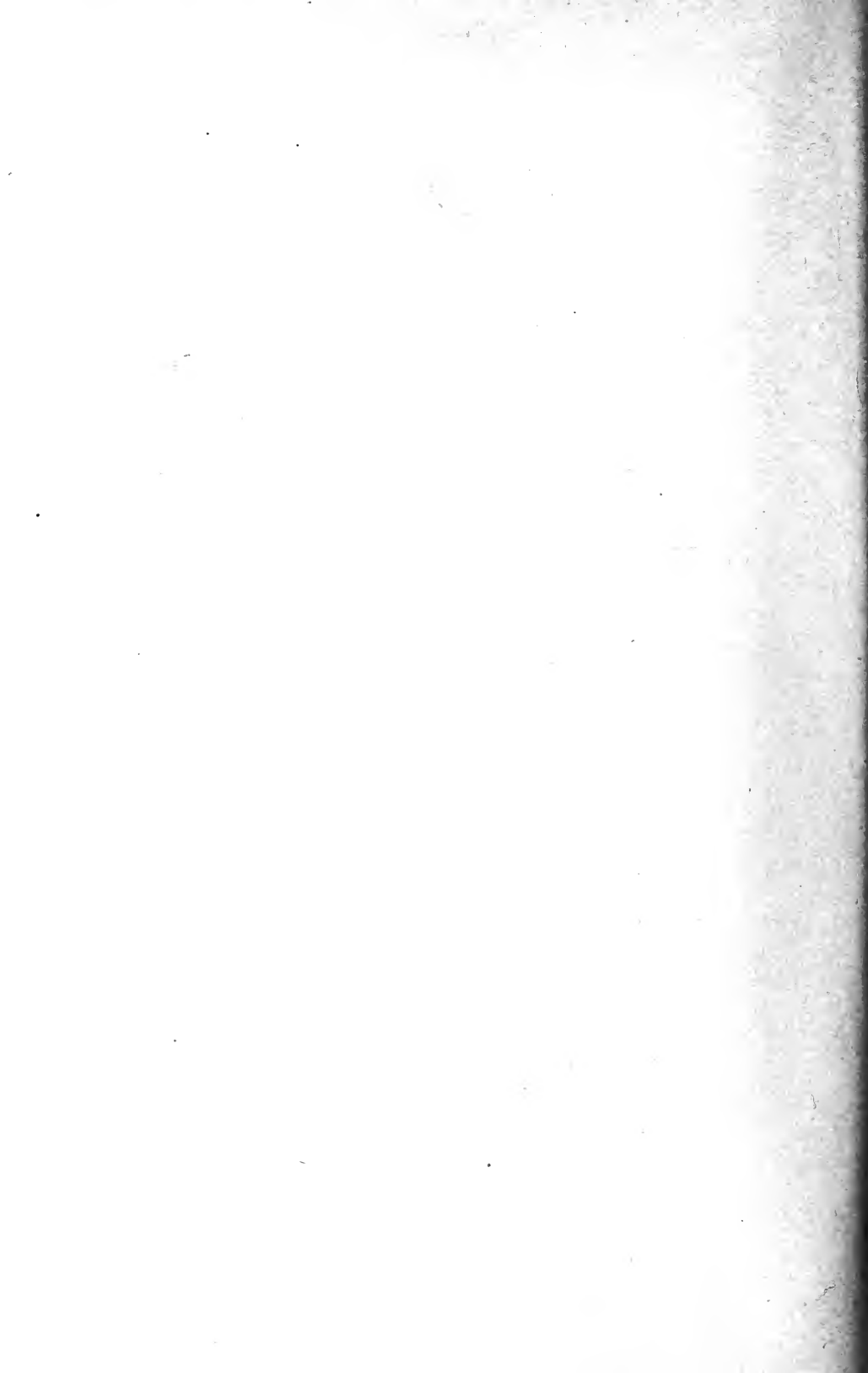
TARTAR EMETIC. See Antimony.

TOBACCO. See Nicotine.

VARATRINE. (Veratrum.) Pain, retching, vomiting, purging, vertigo, weak heart and pulse. *Treatment.*—Promote vomiting if necessary, brandy or coffee enema, keep body warm and in recumbent position.

ZINC SALTS. Pain, vomiting, purging, etc. *Treatment.*—Emetics if necessary, white of egg in milk, tea, tannin, magnesium sulphate, soap, magnesia in water or milk.





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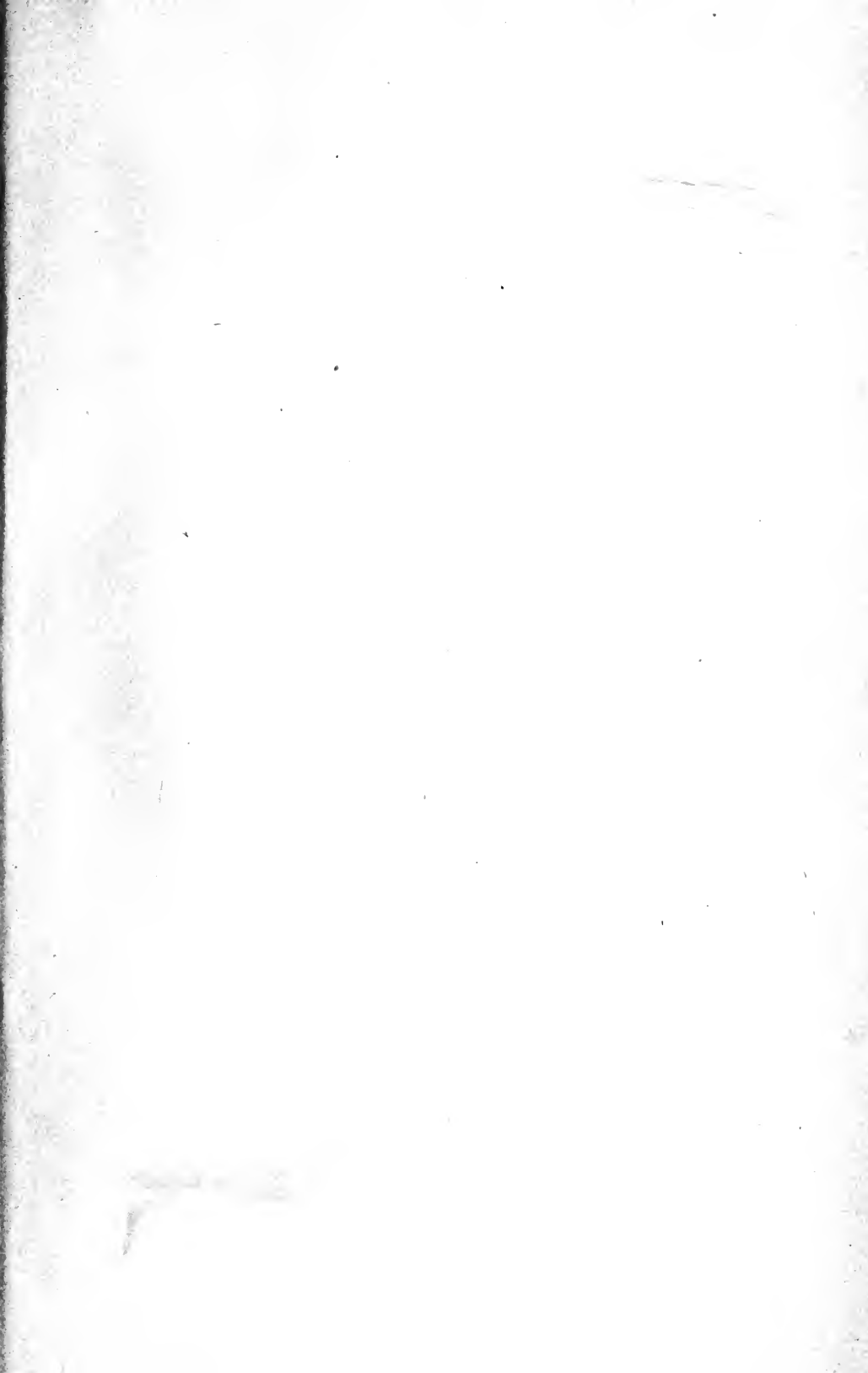
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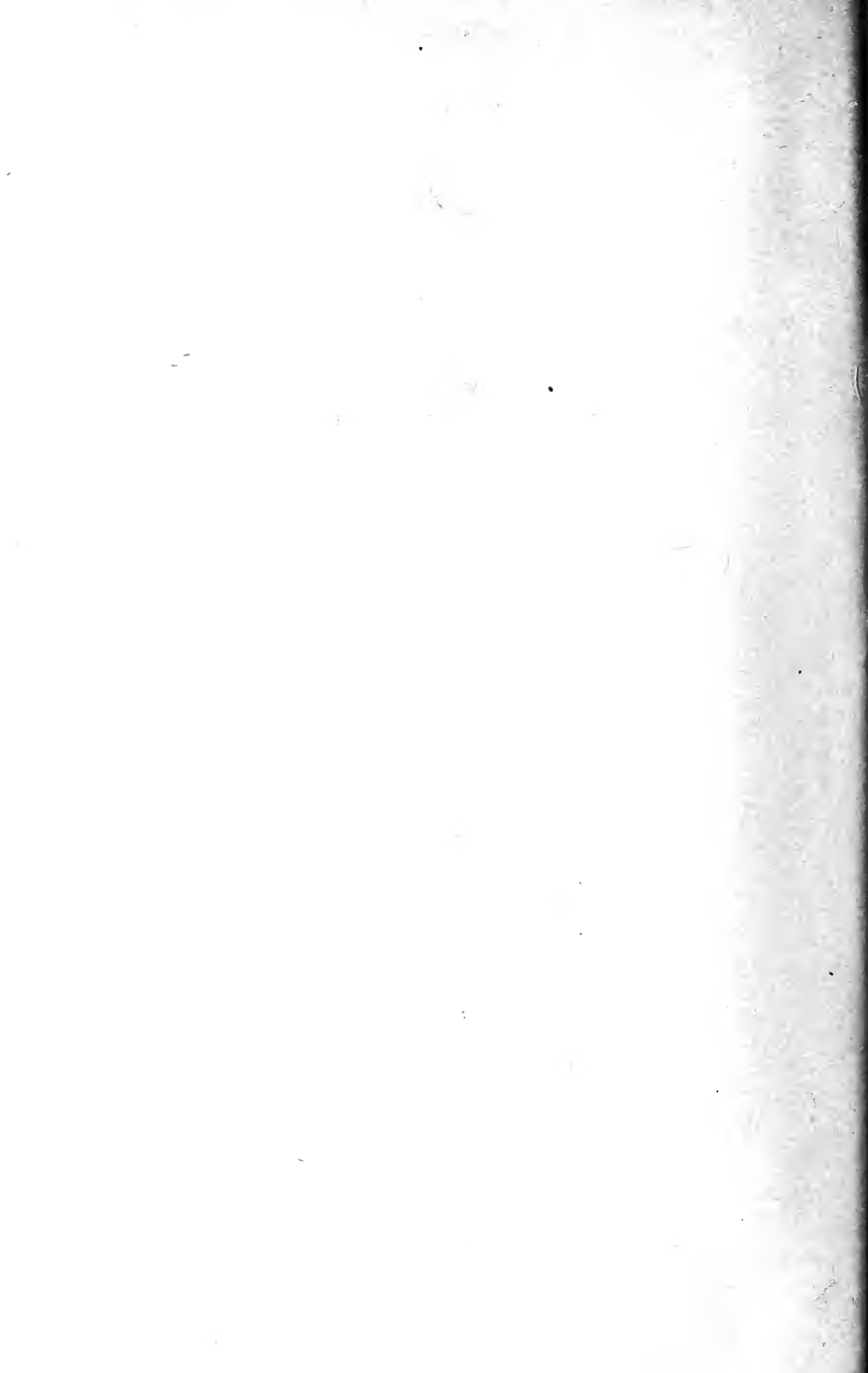
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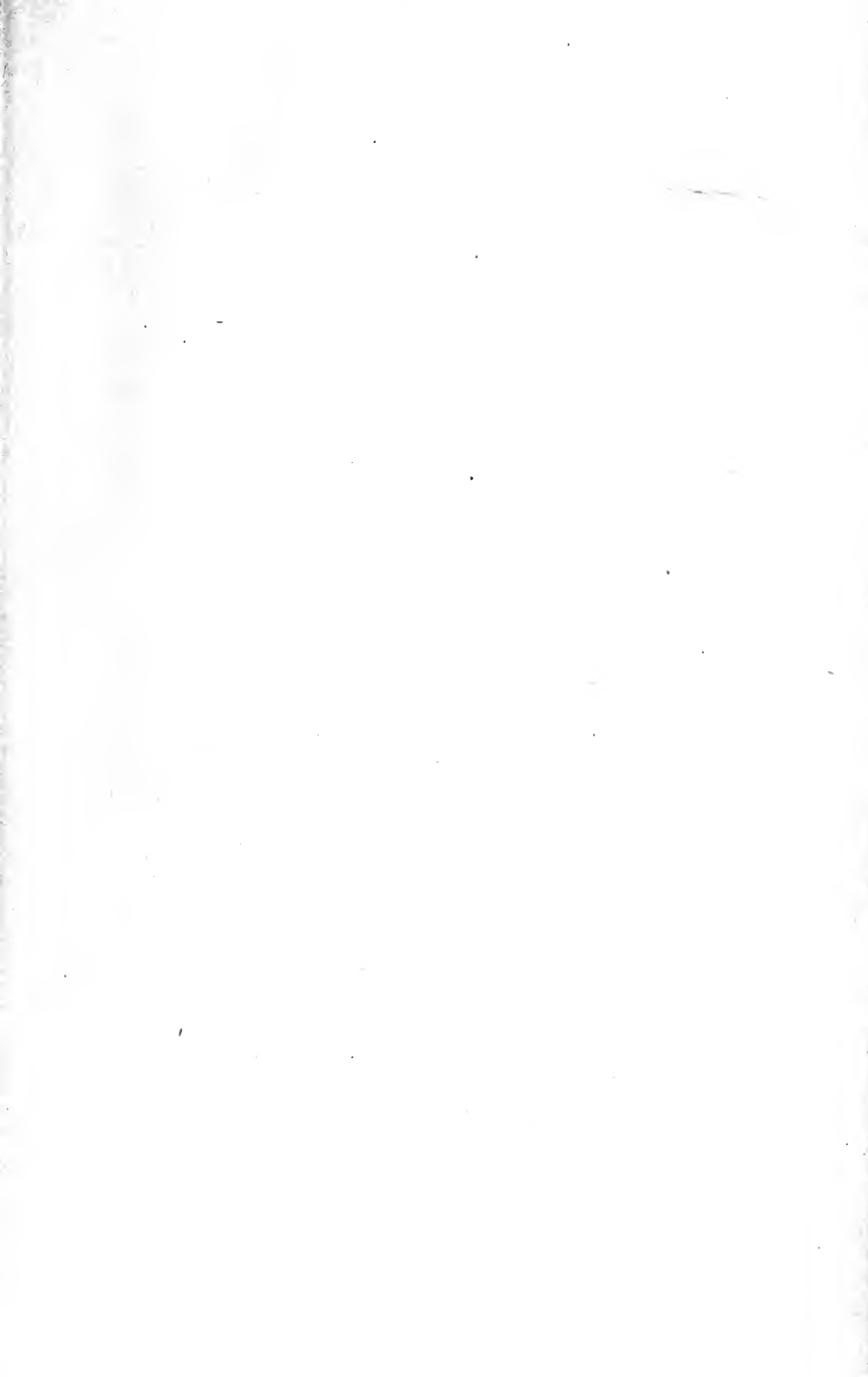
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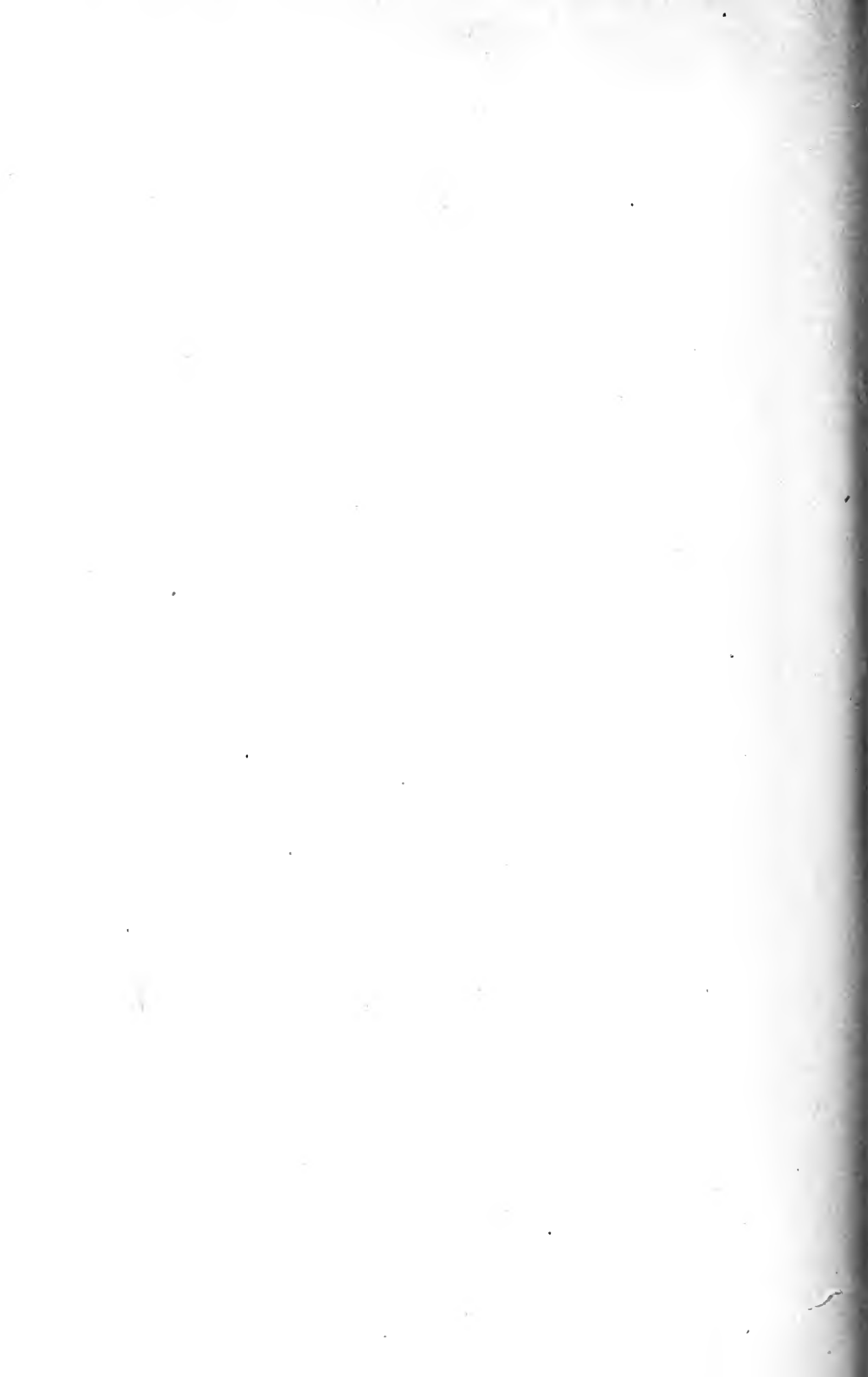
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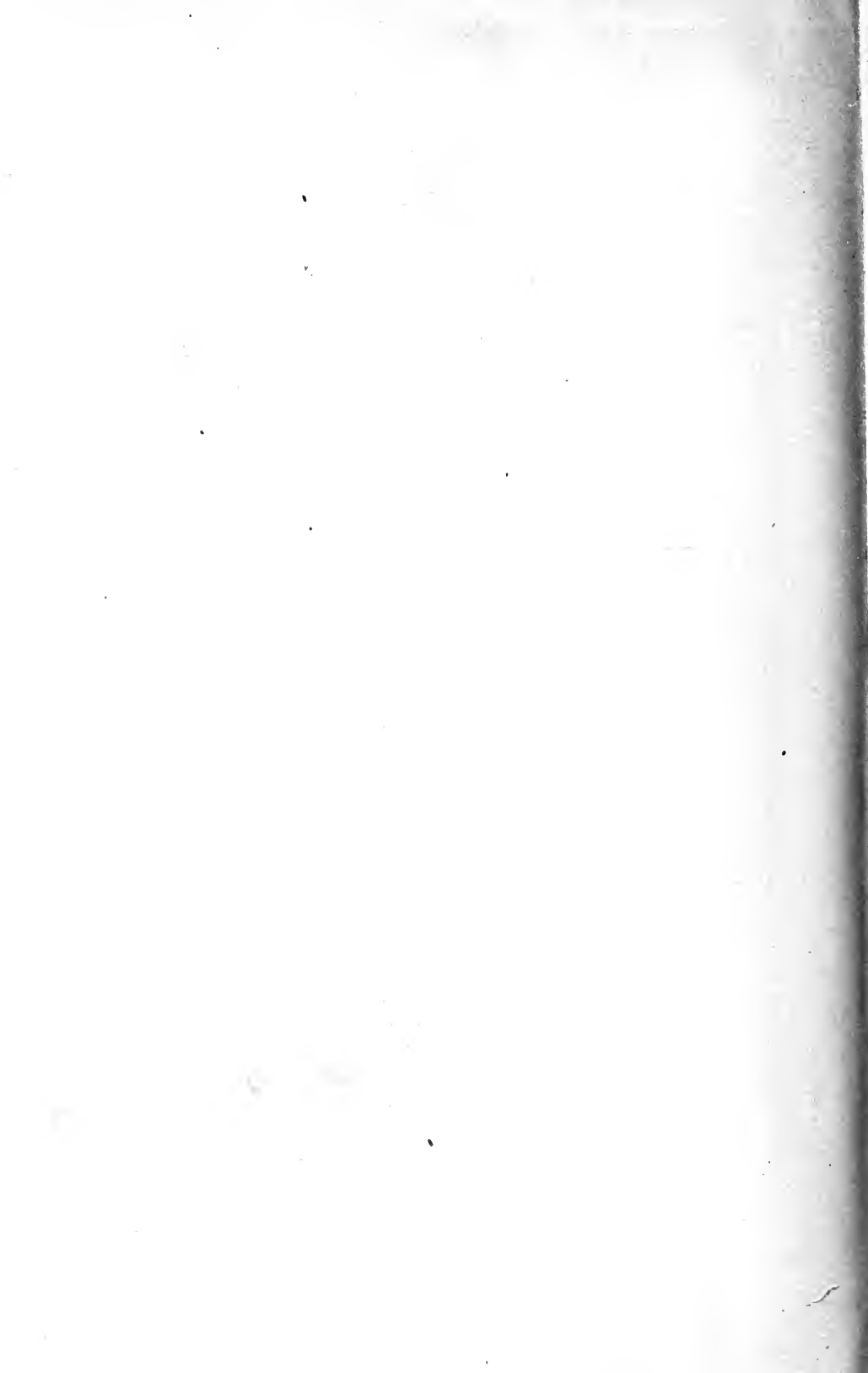
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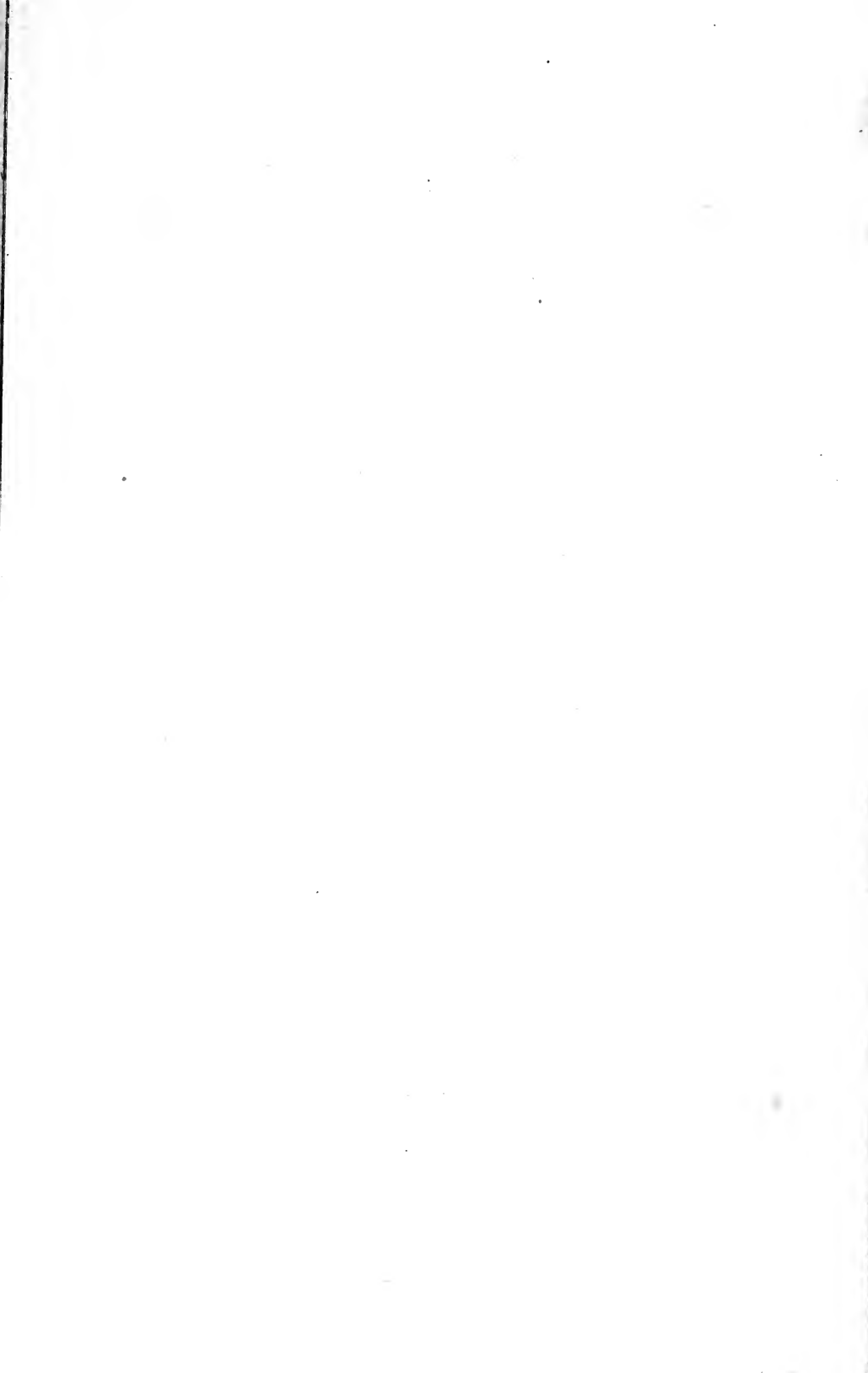
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